FY98
Command, Control, Communications, Computers & Intelligence
C^4I
Technology Area Plan

C^4I at Rome Laboratory

Air Force Research Laboratory
Wright-Patterson AFB, OH

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NOTE:

This Technology Area Plan (TAP) is a planning document for the FY98-02 S&T program and is based on the President's FY98 Budget Request. It does not reflect the impact of the FY98 Congressional appropriations and FY98-02 budget actions. You should consult RL/XP for specific impacts that the FY98 appropriation may have had with regard to the contents of this particular TAP. This document is current as of 1 May 1997.

VISIONS & OPPORTUNITIES

In order for the Air Force to continue into the 21st Century as the world's best and most respected, it must evolve those core competencies that provide properly trained people, superior equipment and the right information — at the right place and at the right time — concerning its own forces and those of any adversary. While *Global Reach - Global Power* helped us develop a solid foundation for

CORE COMPETENCIES COMPARISON

GLOBAL REACH - GLOBAL POWER	GLOBAL ENGAGEMENT
AIR SUPERIORITY	AIR AND SPACE SUPERIORITY
SPACE SUPERIORITY	GLOBAL ATTACK
GLOBAL MOBILITY	RAPID GLOBAL MOBILITY
PRECISION EMPLOYMENT	PRECISION ENGAGEMENT
INFORMATION DOMINACE	INFORMATION SUPERIORITY
	AGILE COMBAT SUPPORT

operations following the Cold War, *Global Engagement: A Vision for the 21st Century Air Force* serves as the framework for planning how we'll operate in the first quarter of the coming century.

As we look to the future, the nation will continue to need a strong military. We will be called on to protect US interests, whenever and however they are threatened. We must respond to advances in science and technology, adapt to new challenges and missions, and protect against surprise. With fewer bases overseas, more military operations will be launched from the United States into areas we've rarely or never seen before. And with global, touch-of-the-button communications, we must dominate the information battlefield.

For this reason, C^4I is more important than ever, and a critical element in ensuring that the Air Force can fulfill its mission. Our military forces, although reduced in size must be highly flexible, globally responsive, and at times deadly precise. They must operate successfully in high threat, high technology environments, and in new missions such as humanitarian assistance where the threat and technology may be low but still potentially deadly. With revolutionary C^4I technologies, we can achieve information superiority; responding accurately and effectively to the rapidly changing international scene and controlling both the increasing instability of the battlefield, and the likely sophistication of our adversaries.

Our quest is simple. We want to ensure that our warfighters have an integrated framework for a command and control vision that will guide the acquisition process and develop a unifying concept for Air Force C2 investments. We

want to establish a backdrop of attributes that will ensure technology is there when it is needed and fits anyone's C2 vision. These shared attributes and the critical functions they spawn are:

GLOBAL AWARENESS

- Consistent Battlespace Knowledge
- Precision Information
- Global Information Base

GLOBAL INFORMATION EXCHANGE

- Distributive Information Infrastructure
- Universal Transaction Services
- Assurance of Service
- Global Connectivity to Aerospace Forces

DYNAMIC PLANNING/EXECUTION

- Predictive Planning and Preemption
- Integrated Force Management and Execution
- Execution of Time Critical Missions/Real Time Sensor-to-Shooter Operations
- Joint, Combined and Coalition Operations

Our current C^4I systems support our forces world-wide. They are the eyes and ears of *Global Engagement* — the notebooks and decision aids, the infrastructure for effective information superiority. The C^4I technologies described in this Technology Area Plan (TAP) support our present systems, but look strategically to the future. These technologies will support a smaller force, but one that still has global responsibilities. These technologies are also in the forefront of the technology revolution with regard to how future wars are fought and won. Technologies in signal processing, data fusion, information warfare, mission planning, communications, artificial intelligence, distributed information systems, intelligence exploitation, new semiconductor materials, multispectral active and passive sensors and cost effective C^4I system support technology will ensure that the appropriate information is available to effectively use our stealth and smart weapons.

Where applicable, C^4I technologies will leverage commercial R&D in communications, computer systems, artificial intelligence, and other related areas. This allows us to concentrate scarce AF resources on those problems that have no commercial equivalent.

Conversely, C^4I technologies in other areas such as signal processing, photonics, and intelligence are having tremendous dual-use potential in areas such as health and criminal justice — our defense investment continues to reap commercial dividends as well.

Improved C^4I technologies will allow us to plan more effective joint operations and more effective coalition ventures by increasing interoperability — and will free operational commanders to concentrate on strategy, operations and tactics. These technologies will enhance the commander's view of the battlefield, the timeliness of his decisions, and the expansiveness of his control. These technologies will provide solutions to some of the most vexing problems facing the DOD today including:

- Maintaining near perfect real-time knowledge of the enemy and communicating that information to all forces in near real time
- Integrating situational assessment, planning, and force execution to ensure the most appropriate force is used to achieve the objective with minimum casualties and collateral damage

In short, as *Global Engagement* and the use of smaller, integrated, highly adaptable forces become the dominant theme in Air Force operational thinking, the ability of C^4I systems to manage information and support battle management grows ever more critical. The C^4I technologies under development at Rome Laboratory will allow the warfighter to operate in a global environment at all levels of engagement. The programs described in this TAP will ensure that we build the technological foundation for both evolutionary improvements in current systems and revolutionary development of new capabilities for *Global Engagement*. Our objective remains:

TOTAL CONTROL TO THE WARFIGHTER THROUGHOUT THE BATTLE SPACE

This plan has been reviewed by all Air Force Laboratory commanders/directors and reflects integrated Air Force technology planning. We request AFAE approval of this plan.

RICHARD R. PAUL

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Information Dominance

The Information Warfare program at Rome Laboratory supports the goals of Global Engagement by addressing the technology to provide Full Spectrum Dominance. Full Spectrum Dominance requires Information Superiority: the ability to collect, process, analyze and disseminate information, while denying the adversary's ability to do the same. A major component of Rome Laboratory's Information Warfare technology program is keyed toward protecting the critical information and infrastructure necessary in performing command and control. The technology is concerned with the confidentiality, integrity and assured service of the information infrastructure necessary to conduct joint warfighter operations, protecting the information infrastructure from adversary information attack, and recovering from successful adversary attacks. The overarching goal of the technology program is Information Superiority for Global Engagement.

Additionally, these same Defensive Information Operations can be used to deny the adversary critical information resources necessary for conducting operations. Rome Laboratory's Information Warfare program clearly addresses the technology for achieving Full Spectrum Dominance and contributes to the goals of Global Engagement.

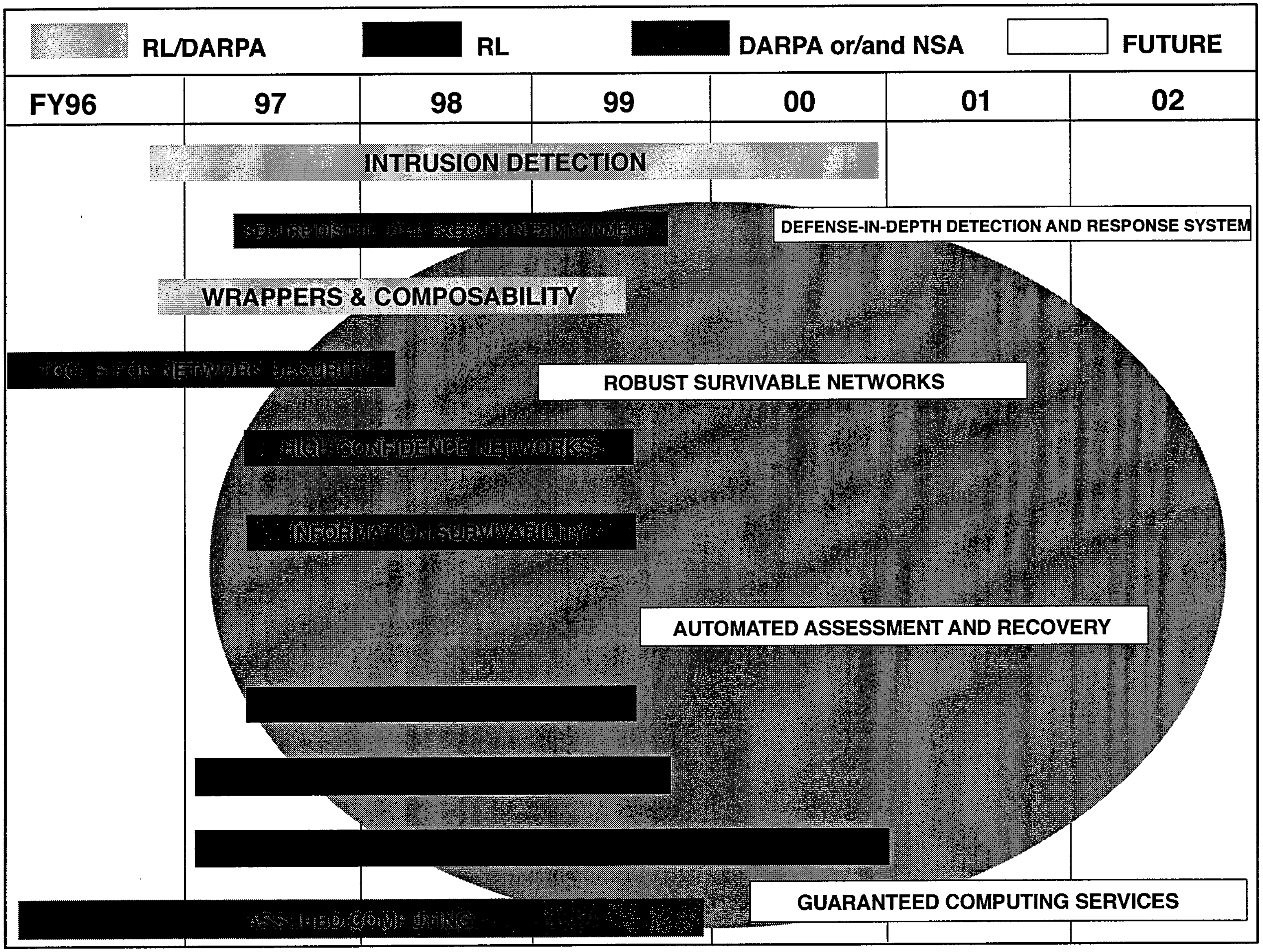
In preparing to implement the new Air Force, as envisioned by the CSAF, we need to begin laying the foundation for a highly accurate, effective and efficient Space and Air Force. One critical element of this foundation is the ability to use and control information. The importance of information in the day-to-day operations of the Air Force, as well as during critical wartime activities, is demonstrated by the creation of Information Operations at a level comparable to Air and Space Operations.

Information Operations spans the spectrum of conflict from peacetime to crisis to wartime and back to peace. The Information Operations goal is the control of information, both ours and our enemies. When this control has been achieved, one has achieved Information Dominance. A key component of gaining Information Dominance is the ability to secure and protect the global information grid while providing the warfighter with correct information in a timely manner. The key technical challenge in this arena is the development of technology that provides unconstrained use of cyberspace in the face of multiple information threats.

The ability of the grid to serve all warfighters, in joint and coalition operations, will probably be limited, even in the long-term, by information security and access control requirements and restrictions. These technologies are just emerging and can be difficult to integrate and use. Similarly, DoD's desire to use commercial services and Commercial Off-the-Shelf (COTS) systems/equipment will open the door for increased information warfare threats against the US. Since the DoD is more dependent on information technology than its adversaries, technology development to protect DoD grid assets is of paramount importance. While protection of information operations is accomplished throughout this spectrum, during crisis and wartime modes, Information Operations transitions to Offensive Information Warfare, and likewise, information protection transitions to Defensive Information Warfare.

In response, Rome Laboratory has initiated an Information Warfare technology program as a part of the Information Dominance area of emphasis. The baseline for this area of emphasis consists of a subset of the technical areas of Distributed Information Systems, Communications, and Defensive and Offensive Information Warfare. That subset is most closely associated with the emerging "smart" systems and their supporting communications infrastructure. The AF S&T baseline program in Distributed Information Systems and Communications is responsive to the current technology issues. The AF S&T baseline for Information Warfare is not. As defined by the CSAF, Defensive Counter Information (DCI) is any action taken to protect our information and its functions from denial, exploitation, corruption, or destruction. Within the Rome Laboratory Information Warfare Initiative, this protective capability is addressed by research and development in four key activity areas. These areas are Integrity & Availability, Damage Assessment and Recovery, Risk Assessment/Management, and Indications & Warning. To form the baseline of this overall Defensive Counter Information program, the small AF S&T Defensive Information Warfare Baseline is supplemented by leveraged outside funding. The leveraged outside funding is mainly from the DARPA Information Survivability program and the Air Force's Project Firestarter — all being conducted at Rome Laboratory. This work forms the major portion of funding for the Baseline. The DARPA program focuses on basic research in Survivability, Intrusion Detection, Composability and Assurance, while the Firestarter focus is on bringing these developments into testable, fieldable prototypes. The small Air Force S&T baseline funding also focuses on transitioning the leveraged dollars, as well as filling in some small, AF unique, gaps in an overall Defensive Information Warfare program. In total, the entire Rome Laboratory Defensive Information Warfare program provides a tightly focused and strong foundation for meeting the near-term and future needs of the Air Force as it evolves into and sustains its preeminence as a leader in the Nation's military defense.

DEFENSIVE COUNTER INFORMATION



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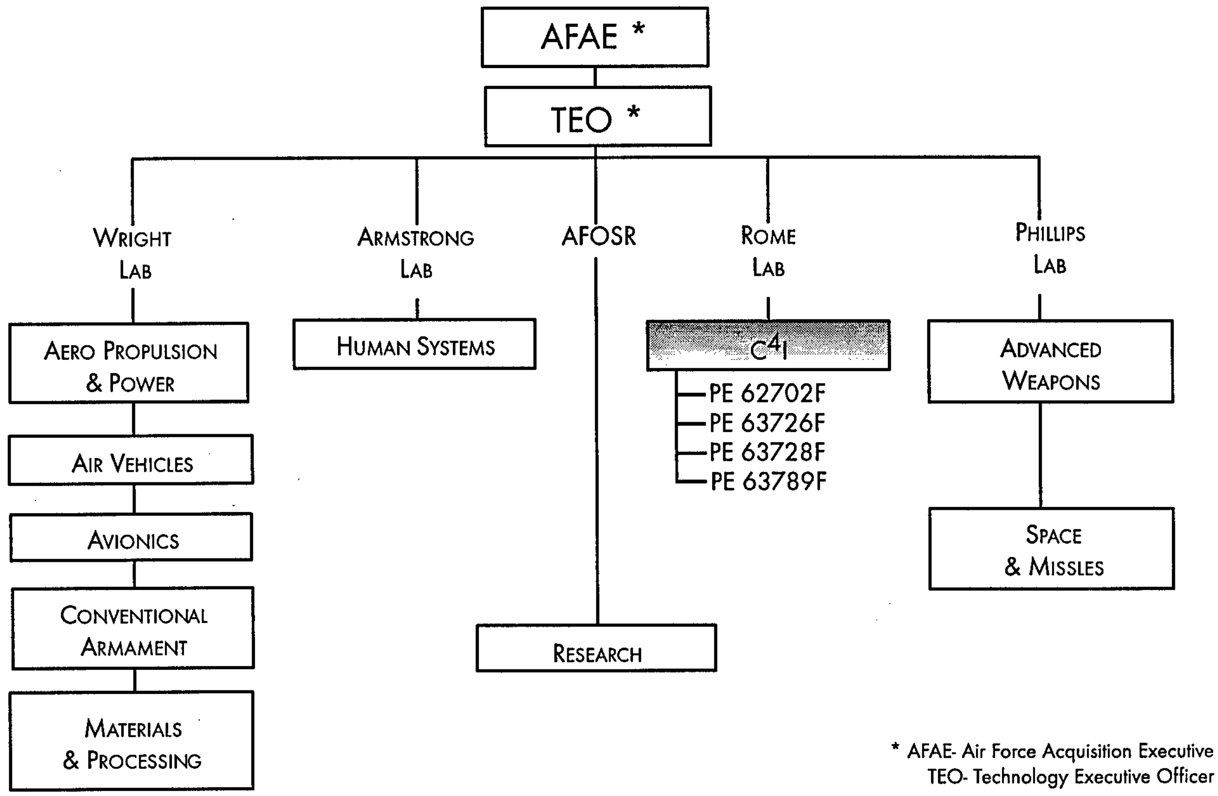


Figure 1. Air Force S&T Program Structure

INTRODUCTION

BACKGROUND

C^4I IN PERSPECTIVE

During 1996-1997, the senior technical staff at Rome Laboratory conducted an extensive study of R&D requirements supporting Air Force Command and Control. This study resulted in a 21st Century Command, Control, Communications, Computers and Intelligence (C4I) R&D Investment Strategy.

The objective was two fold. First, it outlines the basis for the Rome Laboratory Command and Control research community's role in developing the Air Force's Command and Control capability. Second, it establishes a single framework for investment strategy in technologies, both basic and applied, in supporting that C4I Investment Strategy.

The Air Force requires a Command and Control system that directs use of available forces while enabling lightning-fast response to changing situations. With stealthy targets that are very mobile, battle areas which change quickly, and battle assets that are complicated and diverse, the environment for mission execution is extremely dynamic, complex and dependent on many sources of information. These facts are underscored by two key documents, ***Joint Vision 2010 and Global Engagement: A Vision for the 21st Century Air Force.***

Joint Vision 2010 is a DoD document whose guidance has as its focus an increasingly U.S.-based contingency force that can find, fix, track and target anything that moves on the surface of the earth. Among the many areas it addresses is the area of information technology. Joint Vision 2010 emphasizes that the high leverage associated with information technology and modern systems translates into significant improvements that will improve the decision maker's ability to see, prioritize, assign, and assess information in a timely manner. It goes further to state that the fusion of all-source intelligence with the fluid integration of sensors, platforms, command organizations, and logistic support centers will allow a greater number of operational tasks to be accomplished faster. Advances in computer processing, precise global positioning, and telecommunications are shown to provide the capability to determine accurate locations of friendly and enemy forces. These advances will greatly

enhance the ability to collect, process, and distribute relevant data to thousands of locations pushing decision making to lower levels. Forces harnessing the capabilities from these advances will gain dominant battlespace awareness: an interactive "picture" which will yield much more accurate assessments of friendly and enemy operations within an area of interest. This will decrease response time and make the battlespace considerably more transparent. The technology trends which will provide commanders the ability to attack targets successfully with fewer platforms and less ordnance, while achieving objectives more rapidly and with reduced risk, will empower the warfighters as never before.

Global Engagement: A Vision for the 21st Century Air Force addresses the new vision that will guide the Air Force into the 21st Century. It is a rigorous, systematic, multifaceted examination of future demands on the Air Force as a member of America's joint military force, and is shaped, in large part, by Joint Vision 2010. The ability to orchestrate military operations throughout a theater of operations and the ability to bring intense firepower to bear over global distances is a key facet of future warfighting. Global Awareness and Command and Control are called on to give the warfighter unprecedented leverage, and unprecedented advantages.

The Air Force contribution to the Joint Force brings to bear Air and Space Superiority, Global Attack, Rapid Global Mobility, Precision Engagement, Information Superiority, and Agile Combat Support. These are represented as an arch (Figure 2) because they are all mutually supporting and provide synergistic effects. These core competencies are brought together by Global Awareness and Command and Control to provide Air and Space Power to the Joint Force Team.

Figure 2. *Global Engagement*

Global Engagement addresses the need for the capability to dominate an opponent across the range of military operations - Full Spectrum Dominance. Full Spectrum Dominance requires Information Superiority : the ability to collect, process, analyze and disseminate information, while denying an adversary's ability to do the same. Information Superiority is essential to achieving virtually all other Joint Warfighting capabilities. Throughout history, gathering, exploiting, and protecting information have been critical in command and control. The unqualified importance of information will not change in 2010: all combat operations in the 21st Century will depend on real-time control and employment of information. What will differ is the increased access to information at all levels of the force structure, as well as improvements in the speed and accuracy of prioritizing and transferring data which comes about as a result of advances in information technology.

Providing the responsive, high quality data processing and information needed for joint military operations will require more than just an edge over an adversary. Information Superiority will require both offensive and defensive information warfare (IW). Offensive Information Warfare will degrade or exploit an adversary's collection or use of information. It will include traditional methods, such as a precision attack to destroy an adversary's command and control capability, as well as nontraditional methods such as electronic intrusion into an information and control network to convince, confuse, or deceive enemy military decision makers. The effort to achieve and maintain information superiority will also invite resourceful enemy attacks on U.S. information systems. Defensive information warfare to protect the U.S. ability to conduct information operations will be one of the biggest challenges in the years ahead. Traditional defensive IW operations will span the spectrum from physical security measures to encryption. Nontraditional actions will range from antivirus protection to innovative methods of secure data transmission

Command and Control is defined by the Department of Defense Dictionary of Military and Associated Terms (Joint Pub 0-1) as : "The exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission." The operative application of this Command and Control definition includes the enabling capabilities of Communications, Computers and Intelligence: hence the acronym "C4I". In its entirety, C4I involves gathering information, assessing the situation, identifying objectives, developing alternative courses of action, deciding on a course of action, transmitting orders and mon-

itoring execution. This requires a robust network linking all friendly forces and providing common awareness of the current situation.

Currently fielded C4I systems do not support the kind of robust, assured, and timely flow of accurate and relevant information needed to meet the future joint warfighting needs as envisioned in *Joint Vision 2010 and Global Engagement.*

Today we are dealing with an environment that requires the utilization of conventional weapons and requires response to multiple conflicts on interests of differing scales. The intelligence portion of C4I is becoming integrated into the command and control with many of the security barriers and stove pipe systems disappearing. Mission planning is very dynamic and involves a very diverse suite of weapons, surveillance assets and situational awareness information. Systems rely more and more on commercial products that evolve faster than military procurement cycles function. State of the art commercial hardware, driven by workstations and clusters of small, powerful computers tied together in a client-server environment are now part of the military backbone. Software solutions too must utilize commercially available products such as data base managers, operating systems, communications and applications. Reliability and supportability are driven by commercial specifications.

In the post-Cold War world, as we enter a period of Warm Peace, the Air Force must respond to a variety of situations requiring effective use of air power anywhere on the globe, while simultaneously drawing down to a significantly smaller force structure. The Air Force needs improved C4I systems which allow flexible, coordinated use of available forces while enabling lightning-fast response to changing situations. These C4I systems must be reliable in any environment, robust in the face of hostile actions, highly mobile to accompany deploying forces, and affordable. Further, the C4I systems must be able to fully integrate both the warfighting functions and capabilities of component forces - the entire Joint Force. Based on the Joint Vision 2010, Global Engagement and many other C4I Visions, the Rome Laboratory Investment Strategy Process identified the following three Attributes that the 21st Centuary Air Force C4I program must encompass:

- **Global Awareness**
- **Dynamic Planning and Execution**
- **Global Information Exchange**

Global Awareness encompasses the requirements for Intelligence, Surveillance, and Reconnaissance (ISR). It is the umbrella term for the capability that provides consistent battlespace knowledge and precision information in a global information base. Global Awareness develops the common picture of the battlespace, providing enhanced real-time information to the warfighter which is as complete and on demand as required. This is done using existing data sources, creating new data sources, streamlining data analyses, extending the life of sensors in place, enhancing sensor performance, and developing new sensors.

Global Awareness is superior knowledge supported by superior information which enables operational dominance. It entails the operational capability for all pertinent levels of command to know and understand the relevant global military situation on a common, consistent basis. From the Air Force's perspective, Global Awareness must exist at a local as well as a global level. The breadth and scope of Air Force roles & missions, both in benign day-to-day operations and within the context of multiple simultaneous contingencies, demands situational knowledge based on precise information, available on a timely basis, and derived from data extending over the globe. Therefore, Global Awareness also contains a "zoom" capability to allow the situational knowledge to focus and/or expand as required. On-the-scene commanders require common, consistent, enhanced and extended knowledge of the blue, red and gray battlespace; while in sanctuary, force structure planners will be supported by garrison, in-transit weather, and airfield status. As important as real-time, or in-time situational awareness during operational contingencies, is the constant vigil exercised to preclude tactical or strategic surprise through a global awareness built upon indications and warning data and information.

The key role of the Laboratory will be to conduct research to provide better real-time information to the warfighter using existing data sources, by creating affordable new data sources, by streamlining data analyses, by reducing the footprint required to manage Global Awareness, and by extending the life of sensors in place and enhancing their performance.

Dynamic Planning and Execution is the operational capability to rapidly acquire and exploit superior, consistent knowledge of the battlespace in order to shape and control the pace and phasing of engagements. Dynamic Planning and Execution encompasses a total warfare planning process from readiness and deployment planning, to shooter engagement across the full spectrum of foreseeable military operations. All effort is focused on exploiting a superior understanding of the battlespace in order to shape expected actions within the adversary's decision cycle - to proactively engage in rapid, tailorable, planning and execution - integrated vertically and horizontally across mission, functions, and organizations. The intent is to construct agile, robust plans in which near-real time modifications can be triggered by changes in the battlespace while maintaining consistency and minimizing disruption. To this end, distributed and collaborative infrastructures supporting joint, combined or coalition operations, will enable faster than real time option generation and evaluation to achieve in-time assignment or reassignment of assets while maintaining visible objectives-to-

strategies-to-task-to-weapon linkages and rationales. Of primary importance will be the option evaluation capability to determine implications of reassignment or retasking, including options other than hard kill. The bottom line will be to make maximum effective and efficient use of resources and to hold all high-value targets at risk at all times throughout the battlespace while successfully pursuing the Commander's objectives. To accommodate the full scale of Air Force missions, the dynamic planning and execution capability will be scaleable, will minimize the deployment footprint, and will be accomplished by a world-wide distributed decision making infrastructure of virtual battlestaffs and intelligent information specialists.

Dynamic Planning and Execution is the result of the integrated air picture and a new "ready, aim, fire - targeting on the fly" approach to air warfare. It is the iterative process of building the picture, developing a target/logistics queue, executing the queue and building the picture anew. The queue is determined by rules of engagement, weather, mission area guidance and apportionment, and coalition matters, when appropriate. It consists of matching the weapon system to the target, dispatching the weapon, and determining the new target reprioritization set in near real time.

The key role of the Laboratory will be to reduce planning/execution cycle time by (a) developing real-time assignment of assets to missions, (b) accelerating generation and evaluation of options, and (c) enhancing joint and coalition planning & deployment of assets.

Global Information Exchange is the ability to interconnect all members of the Air Force via a netted communications / information system, available everywhere for any task or mission. The ability to communicate, to move raw and processed information throughout a global communications grid, is fundamental to Command and Control. Inherent in this capability is the idea of universal information availability across different transmission media with different characteristics. The Air Force's information network must have global reach for its normal day-to-day operations as well as the capability to allow an instant surge of connectivity and capacity into a localized theater for mobile and fixed-site users. The latter capability is the most difficult and costly to provide but is a very critical and important tool for tactical theater operations.

The key role of the Laboratory will be to enable the development of real-time system management, the establishment of interconnectivity between dissimilar military/commercial networks, the development of counter-information warfare capability, the reduction of the deployed communications footprint and the integration of all airborne platforms (including the shooter). In addition, a key technology resides in the area of defensive information warfare (DIW). This consists of five primary areas - computer/network damage assessment and recovery, integrity and availability, risk assessment and management, indications and warning and data wrappers. Although the commercial sector has many of the same concerns, each of these areas require DoD investment due to unique requirements.

Rome Laboratory's technology program addresses to some degree most of the Air Force Core Competencies shown in Figure 2. Figure 3 identifies the application of the C4I TAP Thrusts to the applicable Core Competencies.

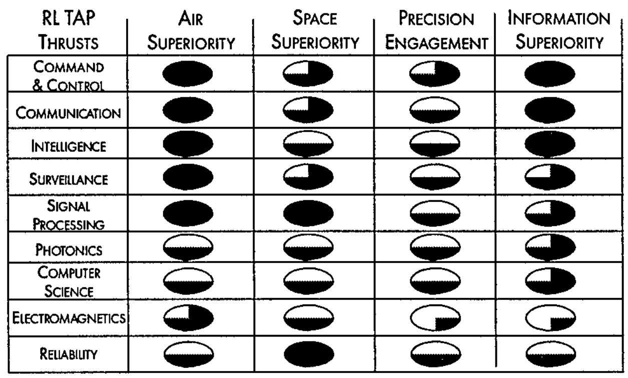


Figure3. *AF Core Competencies/C4I Matrix*

This Technology Area Plan (TAP) describes a focused program of developments and demonstrations across the spectrum of relevant technologies. It is based on the results of the Investment Strategy process which identified roadmaps and a work breakdown structure that defines where research and development must be pursued. This program, within fiscal constraints imposed by limited resources, will provide improvements to both current and future systems required to match Air Force C4I capabilities to operational demands both within the Air Force and the Joint Force.

Figure 4 shows the C4I Technology Area budget allocation within the Air Force Science and Technology (S&T) program. By its nature, C4I is pervasive, and much of the work described in this document is coordinated or conducted jointly with other laboratories, services, and a variety of agencies. This technology program provides significant benefits to both the military and commercial industrial base.

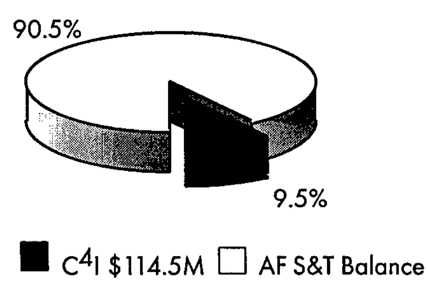


Figure 4. *C4I S&T vs AF S&T*
FY98: $1.203B

As depicted in Figure 4, this Technology Area is projected to receive $114.5 million, or 9.5% of the FY98 AF S&T program based on the FY98 President's Budget request. Note, the program described in this TAP is subject to change based on possible Congressional action.

Recent Accomplishments

The Rome Laboratory C^{4}I program has achieved significant progress over its broad spectrum of technology thrusts:

- The Offboard Augmented Theater Surveillance (OBATS) and the High Performance Computing for Joint STARS Cueing and Correlation (HJC&C) testbeds were integrated in a real-time laboratory test environment. This integration has proven the power of correlated and fused offboard/onboard data when used in conjunction with real-time sensor resource management and represents the bridge to multidisciplinary full battlefield awareness. OBATS developed target acquisition, track and identification factors capable of capitalizing on both strategic and tactical Signals Intelligence (SIGINT) warning to initiate Joint STARS resource management and offboard sensor data selection. The High Performance Computing for Joint STARS Cueing and Correlation (HJC&C) testbed is an advanced simulation of the next generation Joint STARS operator's display implemented on a DARPA Paragon High Performance Computer (HPC). HJC&C demonstrates enhanced Joint STARS radar effectiveness by implementing real-time resource management.

- The Rome Laboratory Space-Time Adaptive Processing (RLSTAP) tool has been utilized to assess the benefits of Space Time Processing techniques for the Advanced Warning and Control System (AWACS). Investigations into this area indicate significant improvement in clutter suppression while minimally impacting the sensor hardware.

- Rome Laboratory efforts in Airborne Reachback communications through FY97 have led to refinements in airborne data messaging protocols and encryption techniques in HF and UHF bands of operation. Extensive experience supporting airmedivac applications has been gained onboard C-130 and C-9 aircraft in support of Operation Joint Endeavor (Bosnia), Global Yankee '96 and Air Care '96. RL developed Airborne Reachback capabilities, designed to be flexible and generic, have proven vital to the airborne telemedicine mission with promise of supporting many more applications. This program was briefed to numerous DoD personnel in FY96/97 including those from AFMC, AMC, ACC, White House Communications Agency, Secretary of Defense Communications inclusive of Gen. Vicillio and Gen. Kadish. 1000 units will be procured.

- A two-channel SPEAKeasy radio was demonstrated at Ft Irwin, CA. This model has a palm-top-computer based remote control unit and operates in HF, VHF, and UHF voice modes. Demonstrations included software reprogrammability, HF-Single-Sideband, SINCGARS, HaveQuick, UHF-SATCOM, and voice-bridging between these waveforms. An embedded Commercial Off the Shelf (COTS) PCMCIA Module for Global Positioning System (GPS) reception was used to synchronize timing. The SPEAKeasy ADMs performed in place of the AN/GRC-206 Radio Pallets with Tactical Air Control Party (TACP) units in the field, replicating the GRC-206 functionality within a smaller weight, size, and power package. We also demonstrated repair of the system using standard Personal Computer parts.

- The Force Level Execution System has been identified for inclusion in the initial operational release of the Theater Battle Management Core System.

- The development of the Joint Defensive Planner was initiated. This tool will support the the Joint Force Air Component Commander (JFACC) in the planning and execution monitoring of the employment of Antiair, Counterair, Active Defense and Passive Defense in conjunction with Offensive Counterair, to destroy or neutralize enemy aircraft and theater missiles.

- The JumpStart phase of the JFACC Battle Management program was successfully completed with a series of demonstrations at the AF C2 Battle Lab. It demonstrated the feasibility of objectives based planning of air operations as a single thread, collaborative activity among dispersed sites. Phase two of this major DARPA led initiative was begun with joint development activities through Rome Laboratory and NRaD.

- A solid state, all polymer battery for military application has been developed. Battery characteristics consist of: high voltage/high charge capacity, rechargeable in 10,000 cycles, operating temperature between -40 degrees Celsius to +55 degrees Celsius, moldable into various shapes and is environmental safe. Research resulted in prototype development and a patent application. In the December 1996 issue of Popular Science this research was praised and received the "Best of What's New" award.

- The Track and Identification Fusion effort under the Rome Laboratory Hostile Target Identification program demonstrated the fusion of data from surveillance, reconnaissance, and intelligence sensors to provide positive and timely identification of air targets, and enhanced situational awareness. Demonstrations and evaluations were conducted for personnel from the AWACS Joint Test Force using E-3 AWACS and TADIL-J data collected during the All Service Combat Identification Evaluation Team (ASCIET-96) exercise.

- The Image Product Archive (IPA) is a standard United States Imagery System (USIS) product archive system. Rome Laboratory successfully transitioned technology from the lab directly to the user for the purpose of querying and retrieving imagery over local area networks. IPA version 1.2.1 is currently fielded at CENTCOM, ACOM, SOUTHCOM, DIA, NPIC, ONI, USAFE, EUCOM, USAREUR, and TUSLA. IPA version 1.2.2 has been installed at 480IG, ACOM, DIA and AHPC, AFTAC and CENTCOM. IPA also supported this year's Green Flag exercise.

- Rome Laboratory successfully demonstrated advanced Message Processing Technology to the HQ USSOUTHCOM J2 and the DoD Counterdrug Technology Development Program Office at Quarry Heights, Panama. The demonstration consisted of several Rome Laboratory developed software packages including the Generic Intelligence Processor (GIP), Identifinder, and the Timeline Analysis System (TAS). GIP is a software toolkit and message parser for the extraction of information from any formatted message. Identifinder is a natural language processing system that extracts named entities from unformatted message traffic. TAS is a visual display and analysis tool which is already operational at HQ USSOUTHCOM. The experiment provides an end-to-end capability to automatically process messages, extract important information, and display the information on maps and timelines.

- The Exercise Timeline Analysis System (EXERTAS) was installed at Hqs Strategic Command and Space Command. EXERTAS was used to build exercise scenarios and automatically generate/disseminate exercise traffic. EXERTAS was used by both commands to support the Bulwark Bronze strategic exercise. EXERTAS increases the productivity of the exercise generation process by a factor of five. EXERTAS is now operational at both commands.

- The Timeline Analysis System (TAS) was recently installed at Hq 12th AF, Davis Monthan AFB, AZ. The 12th uses TAS to perform counterdrug trend analysis in their air component support role to Southern Command. TAS is also operational at Southern Command in Panama and other sites as well. TAS users are now able to share data and analytical results with their counterparts in Southern Command resulting in a much more effective interdiction process.

- The IE2000 Distributed Architecture project is a first step toward the implementation of image processing, archiving, and retrieval functions utilizing Common Object Request Broker Architecture (CORBA) technology. This technology specifies a system which provides interoperability between software objects in a heterogeneous, distributed environment and in a way transparent to the programmer and the user. To date, this project has demonstrated the ability to integrate an existing non-CORBA based imagery database into a CORBA based system architecture, allowing users to interact with this database as if it were a native CORBA object. This also allows other CORBA objects in the architecture to make use of the imagery data contained within this database, without extensive reprogramming of these objects.

- The Multichannel Airborne Radar Measurements (MCARM) program, developed a flexible airborne phased array testbed which provided researchers and technologists with high fidelity high dynamic range real world radar data for the development and validation of Space-Time Adaptive Processing (STAP) techniques. STAP is an advanced signal processing technique which can assist moving radar platforms in suppressing undesired clutter that inhibits or degrades ground and airborne target detection. The currently fielded systems (AWACS, JSTARS, UAV platforms and Navy E-2C), their upgrades, and next generation air and space borne radar platforms will all require some form of STAP processing. The data collected and analyzed from the MCARM testbed is essential for future program growth and enhancements to meet current and future threats. The analysis of the data was the impetus behind the development of the two techniques (referred to as Sigma-Delta STAP and Post Doppler Beamspace STAP) for AWACS. The program also accomplished the first ever integration of onboard HPC to perform real time radar processing of computationally intensive STAP algorithms.

- The joint DARPA and Rome Laboratory Knowledge-based Planning and Scheduling Initiative (ARPI) has successfully transitioned advanced technology from its recent integrated feasibility demonstration. This demonstration enabled transition of ARPI developed concepts and systems to the Joint Force Air Component Commander (JFACC) 2010 JumpStart demonstration. These included an overarching planning representation that allowed for objectives based strategy-to-tasks planning, inspection of plans for omissions and inconsistent elements and temporal reasoning support for plan generation and plan viewing. The demonstration also included the integration of an augmented version of the advanced user-interface plan authoring environment Air Campaign Planning Tool (ACPT) with a wide array of knowledged-based planning tools. Additionally, this demonstration was able to provide the concepts from its plan visualization tool that demonstrated plan viewing over such orthogonal dimensions as plan hierarchy structure, temporal extent of activities and resource availability.

- Rome Laboratory's Knowledge-Based Software Assistant (KBSA) program successfully demonstrated the ability of this revolutionary paradigm to both rapidly and econom-

ically produce software systems as well as yielding unprecidented quality and performance. The joint DARPA and Rome Laboratory Evolutionary Development of Complex Software (EDCS) program started in late FY96 demonstrated initial capabilities in its pursuit of technology to enable continuous evolutionary development of families of long-lived military software systems. The Catalyst system demonstrated the ability to link heterogeneous system life cycle tools, supporting communications and the sharing of data, greatly easing the complexity of system development.

- Global Yankee (GY) is a regional recurring joint training exercise sponsored by the National Guard Bureau and the 152nd Air Central Group. The exercise is designed to provide low-cost, total-force training to National Guard units. Rome Laboratory's Communications Networks Branch engineered a communications backbone with tactical extensions to enable data connectivity between Rome Laboratory assets at a multitude of sites. These included the A-10 Wing Operations Center/Forward Operating Location (WOC/FOL), the Air Operations Center (AOC), Belvedere Air Strip & Range 35 at Ft. Drum, NY, Samaritan Hospital in Watertown, NY, SUNY Health Science Center and 174th Tactical Fighter Wing at Syracuse, NY, in-flight aircraft (C-130), and Rome Laboratory in Rome, NY. The network utilized a primarily Asynchronous Transfer Mode (ATM) based infrastructure. Various media were used to provide the required communications links, including high and low bandwidth radio, fiber optic, wireline, and satcom. The communications portion of the demonstration had several objectives. These included: (1) To provide reliable, secure, communications to Rome Laboratory applications in support of the Global Yankee exercise. (2) Collect and analyze network traffic to aid in characterizing and modeling future combat communications networks. (3) Assess feasibility and performance of various network security equipment and network management schemes. (4) Determine interoperability of military and commercial communications equipment. (5) Test and optimize communications protocols developed by Rome Laboratory.

- Rome Laboratory demonstrated an advanced scheduling capability during the Global Yankee '96 military exercise. The In-Theater Airlift Scheduler (ITAS) demonstrated how advanced scheduling technology allows the user to automatically generate a flyable schedule given resources such as airports, airplanes, and crews, and given movement requirements including weight, volume, configuration, current location, required location, availability times and required delivery times. ITAS is planned to be used to assist the airlift schedulers generate the airlift schedule for the 1997 Global Apache exercise.

- The success of an operational version of In-Theater Airlift Scheduler (ITAS) at PACAF resulted in Air Mobility Command incorporating this technology into their new corporate system, the Consolidated Air Mobility Planning Systems (CAMPS). In CAMPS an expanded ITAS will not only provide a great speed up of the deliberate planning process, but will also be used to provide automated support for dynamic rescheduling. The need for dynamic rescheduling results from execution monitoring, and from new unforeseen requirements. Computer support for dynamic replanning has not been previously available.

- Rome Laboratory has successfully demonstrated the Rome Laboratory Outage Manager (ROMAN) to the Electric Power Research Institute (EPRI). The main goals of ROMAN are to apply advanced Artificial Intelligence planning and scheduling technology in another complex scheduling domain (nuclear power plant outage management), to evaluate the technology in terms of capability and ease of use, and to create benchmark problems for further research. ROMAN has demonstrated feasible automatic robust schedules for a large set of activities directed at the refueling and maintenance of nuclear power plant outages which satisfy critical safety constraints.

- An optical disk jukebox/magnetic disk RAID (Redundant Array of Independent Disks) hierarchical memory system was delivered and interfaced to the Air Force Intelligence Network (AFINTNET) system at the 480th Intelligence Group in support of dynamic mission planning for ACC warfighters. Beta testing is being performed on the system prior to final delivery of this terabyte erasable optical disk jukebox.

- Rome Laboratory demonstrated the feasibility of using uncooled silicon based detectors for thermal sensing in the Long Wave Infrared (LWIR) band (7 μm to 14 μm). Uncooled infrared sensors eliminate the most costly part of contemporary systems, and can result in cameras that cost 1/2 of those currently being sold.

- A 600 x 800 spatial light modulator (SLM) and a diode pumped laser were integrated and tested in the 3-D memory cube. These technologies make possible the write once, read many times operation of the memory cube.

- Rome Laboratory began fabrication of a small, 48 element photonically implemented SHF phased array antenna that will be part of an advanced technology demonstration of an airborne Defense Satellite Communications System (DSCS) compatible antenna.

- Rome Laboratory developed a microelectronic prognostic reliability monitor to predict impending operational failure of electronic components, modules and systems due to hot carrier degradation and oxide breakdown. These cells are self stressing structures which accelerate failure in

a manner similar to wafer level reliability tests. They have been designed to operate in a stand alone manner with integration into the IEEE 1149.1 Boundary Scan Test Access Port (TAP). The cells and test methodology will be incorporated into future AF system designs, improving predictive maintenance, reducing cost and availability, and improving reliability and maintainability.

Technology Thrusts

This TAP is organized into nine thrusts as summarized in Table 1. The first four are mission area thrusts directed primarily to the C^4I systems of Rome Laboratory's parent Product Center, the Electronic Systems Center (ESC). The remaining five represent Rome Laboratory's corporate responsibilities — emphasizing the technologies that enable enhanced performance, affordability, and availability of electronic systems.

Thrust 1: Surveillance
Thrust 2: Communications
Thrust 3: Command and Control
Thrust 4: Intelligence
Thrust 5: Signal Processing
Thrust 6: Computer Science & Technology
Thrust 7: Electromagnetic Technology
Thrust 8: Photonics
Thrust 9: Reliability Sciences

Table 1. *Major Technology Thrusts*

Figure 5 shows the planned allocation of AF S&T funds among these thrusts, including civilian salaries and other operations and maintenance.

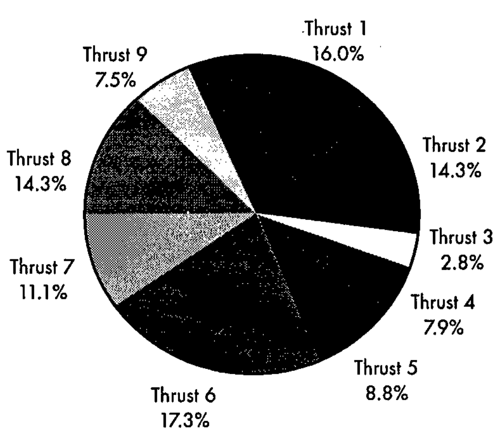


Figure 5. *Major Technology Thrust Funding*

Industrial Programs

Independent Research and Development (IR&D)

Rome Laboratory is a strong proponent of joint partnerships with industry in order to forge meaningful dialogue and research to meet C^4I objectives.

The Industry Looks at Rome Laboratory (ILARL) annual event is a well-established forum designed to update the entire C^4I community on AF plans and requirements and give the community a chance to interact with Rome Laboratory personnel. In addition, Rome Laboratory participates in the Electronic Systems Center's (ESC) Industry Days.

In FY 96 Rome Laboratory implemented the C^4I Reverse Industry Days in order to expand our partnership with industry IR&D in addressing C^4I technology needs. Attendees at the ILARL are encouraged to submit "white papers" showing how their IR&D projects address C^4I needs. Following Rome Laboratory's technical evaluation, industry IR&D Project Managers are invited to the Lab for further discussions to identify potential areas for joint partnerships.

An example is work on stress life testing involving Plastic Encapsulated Microcircuits (PEMs). Rome Laboratory and a major aerospace contractor are pursuing a Cooperative Research and Development Agreement (CRDA) on this effort whereby Rome Laboratory will receive commercial parts being used on a major aerospace development program for our test and evaluation and we will share test and field information on the use of these parts in various applications.

In addition, Rome Laboratory's technical Directorates annually host voluntary and invitational dialogues with industry in their areas of cognizance to exchange current information on IR&D activities. These dialogues include lab presentations of their technology needs and review of industry IR&D projects. MAJCOMs, other DoD, and Federal agencies are included in the IR&D discussions.

The Rome Laboratory investment strategy considers IR&D to assure that its technology plans take advantage of corporate investments and advances. It is through these linkages with industry that we can proactively address the requirements of Global Engagement by leveraging industry technology in these areas.

A few examples of IR&D Success Stories illustrate the importance of IR&D in meeting AF C^4I needs.

- Rome Laboratory's Integrated Bistatic/Electronic Support Measurement technology insertion onto a major intelligence platform leveraged into the platform's prime contractor's IR&D for both data interfaces and platform modifications. The prime's development of related software for navigation and signal information, operator commands and controls to accept bistatic sensor outputs, and platform modifications for the new antenna permit-

ted flight testing of this technology on the platform in varied environmental situations.

- Rome Laboratory and industry have collaborated efforts under Ballistic Missile Defense Organization (BMDO) sponsorship to merge Ground Entry Point (GEP) command, control and communications (C3) ground terminal in-house research with the Ground Based Interceptor/Exoatmospheric Kill Vehicle (GBI/EKV) flight communications package developed by industry. Test and demonstration plans have been cooperatively developed which will include simulated flight test, tracking and communications.

- Rome Laboratory is leveraging a $25M IR&D investment to advance spacecraft communications technologies with six companies. The IR&D investment is directed at developing advanced antenna components for the next generation MILSTAR satellites. This IR&D work is being directly incorporated into EHF payload antenna developments that Rome Laboratory is currently conducting under sponsorship from the MILSATCOM Joint Program Office (MJPO) at the AF Space & Missile Center.

DOMESTIC TECHNOLOGY TRANSFER

The goals of the Rome Laboratory Technology Transfer Program are to:

- improve our communication and interaction with the private sector, state and local governments, and other federal agencies,
- leverage Rome Laboratory's S&T budget, and,
- enhance American competitiveness in the world economy.

At Rome Laboratory, technology transfer is accomplished through the laboratory's pursuit of five areas:

- Rome Laboratory uses Cooperative R&D Agreements (CRDAs) as one of its primary tools to accomplish its technology transfer mission. A CRDA is an agreement between Rome Laboratory and one or more industrial organizations, universities, state or local government organizations, or other federal agencies to conduct specified research or development efforts consistent with the laboratory's mission. Rome Laboratory has entered into 69 CRDAs, and currently has 33 active. The technology being pursued includes every facet of the Rome Laboratory technology development mission.

- Another tool is Education Partnerships (EP). An EP is an agreement between the laboratory and an education institution in the United States to encourage and enhance study in scientific disciplines at all levels of education. Rome Laboratory has entered into 32 EPs to date, and currently has 11 active.

- Grants and Cooperative Agreements are additional methods to effect technology transfer. In 1994 Rome Laboratory received the authority to use these vehicles for research in technical fields related to the laboratory's mission. These new methods quickly became an important way to effectively pursue technology development critical to the laboratory. Their use at Rome Laboratory has consistently increased over the years.

- Responding to requests for technical assistance from private and public entities is another Rome Laboratory technology transfer area. In 1996 our commitment to a hands-on approach and personal interaction resulted in our answering over 270 requests from industry for both information about our technology and for specific answers to technical problems they were encountering.

- Technology transfer is also being facilitated through the negotiation of patent licensing agreements. The laboratory currently has seven license agreements for patents held by its employees and is currently negotiating another two agreements.

The products derived from this cooperative research will provide the private sector and the Air Force with new and improved Information Technology resources. Some examples of RL Technology Transfer successes include:

- A 1996 Federal Laboratory Consortium, Northeast Region Award was presented to Rome Laboratory for its Technology Transfer accomplishments during the year. Rome Laboratory was named the Northeast Region's Laboratory of the Year.

- Rome Laboratory has two multi-partner CRDAs for jointly developing, evaluating, and commercializing software engineering techniques for parallel processing, software quality, and software requirements analysis and specification.

- The completed Sneak Circuit Analysis Tool (SCAT) software is the first automated tool to perform Sneak Circuit Analysis (SCA) on system design schematics. It replaces high cost, labor intensive, manual analysis methods. The low cost of applying the SCAT tool to design schematics has made it cost effective to perform SCA on a wide range of designs where SCA would have been cost prohibitive. The tool has been successfully applied to both military and commercial designs. Commercial applications include the Oregon Public Transit Authority, San Francisco BART system and Ford. Military applications include Army and Air Force systems. A commercial vendor is currently marketing the SCAT tool with great success.

- Under a Partnership Intermediary Agreement, Rome

Laboratory and the New York State Technology Enterprise Corporation conducted a technology evaluation and demonstration to develop the initial components of a prototype, biometric based, voice verification system, for automated border crossing. The system incorporates an infrared (IR) transmitter device for communicating from a moving vehicle, with a fixed computer work station which receives the IR signal and performs voice verification. Voice data from a moving vehicle was collected using the IR transmitter device and then processed with Rome Laboratory's unique algorithms which were able to successfully perform voice verification. This system promises to speed routine commercial traffic boarder crossings at the United States boarders with Mexico and Canada by positively identifying, in near real time, the driver and passengers of vehicular traffic through the use of advance voice verification systems. This project was sponsored and monitored by the United States Immigration and Naturalization Service.

- The Platinum Silicide (PtSi) focal plane array developed and patented by RL has created an exciting technology that is being deployed in the Air Force's B-52 fleet and is also being developed for use in commercial aviation to increase visibility in adverse weather conditions.

- Under an Education Partnership, Rome Laboratory formed a partnership of 24 universities and Rome Laboratory to become the Information Institute. The purpose of the institute is to create a shared research infrastructure among the member institutions to enable collaborative research, to leverage research opportunities within and outside of Rome Laboratory, and to enhance educational opportunities. The Institute concentrates on studies in the fields of Information Sciences including Information Security, Information Fusion, Robust Computing, Networking and Distributed Computing, High Performance Computing, Information Storage and Retrieval, Optical Processing, and Specialized C^4I Research.

- Under the Traffic Flow Visualization and Control (TFVC) Program funded by the Federal Highway Administration, Rome Laboratory is developing a state-of-the-art automated traffic monitoring system that utilizes defense related technologies to detect and report incidents on our nations overcrowded highways to traffic engineers. Successful deployment of an initial capabilities demonstration occurred during the summer of 1995. This system now serves as a developmental testbed for software and hardware upgrades that will lead to the final design of the TFVC system. Through an agreement with the New York State Dept. of Transportation, the final system will be implemented in a twenty-five sensor configuration on the Long Island Expressway during the first and second quarters of fiscal year 1997.

- A breakthrough technology development sponsored by Rome Laboratory was recognized as one of the 1996 Popular Science Magazine's top 100 new products or developments. This technology was the development of an all polymer battery. The prototype is a solid state battery composed of a plastic anode, cathode and electrolyte, with no metal parts. The battery can be molded into any size and shape, will not leak and is lightweight compared to conventional metal batteries. Additionally, it contains no toxic material, and is rechargeable many hundreds of times.

Dual Use Technology Development

Dual Use Technology Development is an initiative to co-develop defense related technologies with private industry and universities to benefit both parties and improve the economic infrastructure and competitiveness of America's industrial base. A major program in this area has been the Technology Reinvestment Program (TRP). Rome Laboratory has been a full participant in this program since its inception in 1993. In 1995 RL was also a full participant in the DDR&E Federal Defense Laboratory Diversification Program. This participation resulted in two awards to RL and its technology development partners in the fields of Speech Processing and Infrared Sensors. Lastly, in FY97, RL is a part of the new DARPA/DDR&E Dual Use Applications Program. Rome Laboratory has submitted four technology topics for consideration in this program, and will evaluate proposals and manage projects resulting from awards in this program.

Small Business Innovative Research (SBIR)

The Small Business Innovation Research (SBIR) Program was established by Congress in 1982 to encourage participation of small businesses in federal research and development initiatives. Additional program objectives include stimulating technological innovation, fostering and encouraging participation of minority and disadvantaged persons in technological innovation, and increasing the commercial application of government supported research.

The benefits of the SBIR Program are complementary: the government gains new, cost-effective, innovative technical solutions to challenging problems while the small business is given the opportunity to market its SBIR technology to the private sector, a process which stimulates the US economy.

Rome Laboratory works jointly with Electronic Systems Center (ESC) in promoting small business initiatives via the SBIR Program. Rome Laboratory manages all SBIR contracts supporting C^4I technology and ESC manages all SBIR contracts supporting systems engineering projects. Together, Rome Laboratory's and ESC's SBIR budget is approximately

$25 million in 1997.

SBIR successes include:

- Rome Laboratory initiated the development and demonstration of airborne HF Bistatic Synthetic Aperture Radar (BISAR) technology with tomographic processing for the imaging/detection of large objects below ground. The measured data will indicate optimum frequencies for penetration and resolution of buried and obscured targets for future advanced technology efforts. Application of BISAR and tomographic imaging techniques at HF frequencies form the basis of the experiment since HF signals propagate through foliage and into the ground. A baseline bistatic testbed system will exploit illuminations from existing and mobile transmitters to detect targets by forming bistatic images of the target returns.

- Under a 1996 Phase I Small Business Innovation Research (SBIR) project, a concept for developing an image processing component software capability for the Image Exploitation 2000 (IE2000) Facility was designed and initially demonstrated. This Common Object Request Broker Architecture (CORBA) based framework is planned to be integrated into the IE2000 Leading Edge Services (LES) and SIPRNET communication circuits to allow other networked organizations and users to download and assemble custom platform independent applications from the IE2000 warehouse of image processing algorithms.

- Rome Laboratory's Project Management Report Generation and Automatic Documentation Generation efforts have successfully demonstrated the application of linguisticly-based natural language text generation in the software development domain. This capability integrated in both experimental and commercial development environments provides both conventional documentation and dynamic explanations or "help." This technology has also been combined with natural language understanding capabilities to enable translation from one language into another.

International Programs

In addition to being on several international panels, Rome Laboratory is currently active in 29 International Agreements with 11 foreign governments. The International Cooperative R&D Program has enhanced Rome Laboratory's technology base by leveraging the technology developments of our allies valued at over $30 million.

Other Government Labs /Agencies

Air Force S&T Programs

The four Air Force superlabs work continuously to clarify and coordinate their programs. Rome Laboratory, Wright Laboratory and Philips Laboratory have jointly developed a single technology program plan for Communications. Other examples include a Memorandum of Understanding between Rome and Wright Labs in the area of airborne communications, and with Armstrong Lab for the intelligent tutor program. Rome Laboratory maintains a continuing dialogue with Wright Lab in electromagnetic technology. Rome Laboratory works together with Phillips Lab to transition C^4I technologies to space applications.

Rome Laboratory, Wright Laboratory and Phillips Laboratory responded to AFMC/ST's direction to pursue more cross-laboratory integration by initiating coordinating plans in the areas of Surveillance, Signal Processing, and Automatic Target Recognition. The plans identify the technology directorates involved, the corporate vision for each area, the role of each directorate in contributing to the vision, the funding profile for each directorate, and a top level roadmap which depicts how each directorate's projects and funding contribute towards an integrated, nonduplicative set of end products.

A few joint program examples are:

- Rome Laboratory and Phillips Laboratory work together in supporting technology developments sponsored by the MILSATCOM Joint Program Office at the AF Space & Missile Center. These efforts are currently focused on advanced space qualified processor and antenna technology for the next generation MILSTAR satellites.

- The Rome Laboratory Space Communications Branch and Antennas Branch are coordinating with Wright Laboratory in the development of future wideband airborne communications antennas. Wright Laboratory will perform flight demonstration of various antenna prototypes to verify system effectiveness.

- We work closely with both Wright Laboratory and Phillips Laboratory in the development of sensor data fusion technologies. Our distributed multiplatform fusion technology is complimentary to a number of major programs at Wright Laboratory including Moving and Stationary Target Acquisition and recognition (MSTAR) and Foliage Penetration (FOPEN), and it is the enabling technology which will integrate evolving space based surveillance and augmentation sensor concepts being developed by Phillips Laboratory.

- We also work closely with both Wright Laboratory and Phillips Laboratory in the development of a Space Based Radar capability under the Air Force Space Sensors 2000 Study. Initial rounds of coordination have resulted in several joint efforts between the laboratories to support this concept. Rome Laboratory is providing Space-Time Adaptive Processing, active aperture radar architecture,

and bistatic radar variant technologies.

- We work closely with Wright Laboratory in the application of Wright Lab developed Automatic Target Recognition (ATR) technology to the Joint STARS platform. Under both the Theater Missile Defense Surveillance and Counterproliferation Programs we are applying Wright Lab developed ATR algorithm technology to the detection and identification of SCUD missile Tactical Erector Launchers (TEL's). These two ACC and SAF programs, respectively, have been technically integrated by us and have the highest priority from ACC and SAF.

- We also work closely with Wright Laboratory in the general area of Image Exploitation Automatic Target Recognition (ATR). Wright Lab/DARPA sponsored initiatives such as Semi-Automated Image Intelligence (IMINT) Processing (SAIP), Image Understanding (IU) and Moving and Stationary Target Acquisition and Recognition (MSTAR) are ATR baseline programs which are directly related to our DARPA sponsored Moving Target Exploitation (MTE) program. Our MTE Virtual Testbed (MTEVTB) program is an evolutionary program which will provide a real-time capability of evaluating Wright Lab ATR technologies for applicability and transition to Joint STARS.

- DARPA, Rome Laboratory and Wright Laboratory formed a partnership and developed a tool for modeling and analysis of advanced radar system concepts. This effort leveraged work done by RL, WL and members of The Technical Cooperation Program (TTCP). Rome Laboratory contributed RLSTAP/ADT and computational electromagnetic models, Wright Lab contributed SAR and FOPEN models, and TTCP members contributed clutter and jammer models.

- The Rome Laboratory Hostile Target Identification program addresses positive, timely identification of air targets using intelligence, surveillance and reconnaissance (ISR) platforms such as Rivet Joint, AWACS and Joint STARS. These activities are closely coordinated with Wright Laboratory Non-Cooperative Target ID (NCTI) efforts which address target identification deficiencies for fighter aircraft.

- Rome Laboratory, together with the other three Air Force Superlabs, formed and staffed an elite panel to conduct a comprehensive review of long lead Modeling and Simulation-related technologies in order to identify those areas that would be of high interest or significance to the USAF for constructive, virtual, live or hybrid simulations.

- We joined representatives of Armstrong, Wright and Philips Labs, Test Centers, Logistic Centers and Product Centers to discuss, for the first time, the role that Air Force Modeling and Simulation will play in an environment of shrinking budgets, base closures and reduction of capabilities, and to scope the issues of employing Modeling & Simulation (M&S) in the acquisition process.

- Rome Laboratory and Wright Laboratory collaborate on all work performed in the non-cooperative target identification/hostile target identification arena. All work is coordinated and deconflicted in joint meetings with the Air Force Combat Identification Integrated Management Team. The Rome Laboratory Hostile Target Identification program addresses positive, timely identification of air targets using surveillance, reconnaissance, and intelligence sensor platforms such as AWACS, JSTARS, and Rivet Joint. These activities are closely coordinated with Wright Laboratory Non-Cooperative Target Identification (NCTI) efforts which address target ID deficiencies for fighter aircraft.

- Rome Laboratory and Armstrong Laboratory are working together on a New World Vistas effort aimed at addressing Air Intelligence Agency's (AIA) need for a Decision Support System (DSS). Rome Laboratory is performing basic research in Natural Language Understanding (NLU), with emphasis on complex event extraction. Armstrong Laboratory is performing basic research in Advanced Information Visualization, with emphasis on cognitive techniques for conceptualizing complex events, temporal and spatial patterns, and decision-making.

- Rome Laboratory is collaborating with Wright Lab Materials Directorate to provide phosphorous injection expertise and crystal growth expertise in zinc geranium phosphide (ZnGeP2) for mid-Infrared Optical Parametric Oscillators needed by WL. We also are providing bismuth silicate crystals to the Wright Lab Materials Directorate for laser protection experiments.

- Rome Laboratory and Phillips Laboratory are collaborating to determine whether radiation processing can improve the properties of bismuth silicate optical signal processing materials.

- Rome Laboratory and the US Military Academy Physics Department are collaborating on applying photorefractive materials and methods to real-time imaging of fluid flow and turbulence phenomena.

- Rome Laboratory is a Technical Sponsor (together with Wright Lab) for the highly successful Title III (Defense Production Act) Program on Gallium Arsenide Substrates and has evaluated wafers and provided feedback to the commercial GaAs wafer manufacturers who are participating in the program. Rome Laboratory and Wright Laboratory will collaborate in an upcoming Title III Program on Indium Phosphide Substrates.

- Rome Laboratory has an on-going joint effort with Wright Laboratory entitled "Computational Electromagnetics (CEM) Technology Enhancements." This objective of this effort is to develop a CEM tool based on the finite element method that can be used to analyze and design broadband flush mounted antennas such as circular log-periodics and modulated arm width, multi-armed spiral antennas. This tool will be capable of simulating non-cylindrical cavities, non-planar material layers, anisotropic materials and it will automatically generate the defined antenna models.

- Rome Laboratory in conjunction with Wright Laboratory, are developing Very High Speed Integrated Circuit (VHSIC) Hardware Description Language based tools and methodologies to facilitate the re-engineering of digital avionics which have become obsolete. The effort will identify and create computer aided engineering technologies which support the efficient re-engineering of obsolete components, boards, and subsystems.

- Rome Laboratory continues to work with the Army Research Laboratory (ARL) on enhancing and customizing the GEMACS (General Electromagnetic Model for the Analysis of Complex Systems) code to meet their specific requirements. A direct interface between the output of the BRL-CAD drawing program and the Input Language Processor (ILP) of GEMACS has been developed which significantly eases the analysis model development process. A hypertext help and tutorial guide have also been developed and installed on the ARL workstations.

Government Agencies

Rome Laboratory is very proactive in establishing relationships and working with other government agencies and the MAJCOMs in order to leverage the C^4I technology program. A few examples are:

- Rome Laboratory is working with DARPA under the Airborne Communications Node (ACN) and Warfighter Internet (WI) programs. These programs also involve tri-service partners and are focused on advanced concepts for using manned and unmanned air vehicles for sensor and communications relays.

- Rome Laboratory is working with the J-STARS program office and the MILSATCOM terminal program office at Electronic Systems Center (ESC) in the definition and development of a MILSTAR Medium Data Rate (MDR) terminal/antenna capability. This effort is building off current commercial airline developments for low cost, wideband Ku-band antennas supporting the evolving pay-per-view television market. These low cost antennas are being translated for operation at 20 and 44 GHz to support data rates up to 1.544 Mbps from C2 aircraft.

- Rome Laboratory is working with DARPA, Air Combat Command, the AF C2 Battle Lab, NRaD and the Navy Battle Lab in the execution of the Joint Force Air Component Command (JFACC) Battle Management program which will develop a revolutionary command and control capability for the JFACC.

- Rome Laboratory, together with DARPA and Naval Command and Control and Ocean Surveillance Center's R&D Division (NRaD), sponsored a major demonstration of collaborative planning as part of JWID 96. The demonstration involved sites at Ft Bragg and at Shaw AFB, and included coalition planning activities involving representatives from the TTCP.

- Rome Laboratory and the Air Force Communications Agency (AFCA) have initiated a collaborative effort in the area of digital, wireless High Frequency (HF) messaging. The nature of the collaboration is hands-on engineering, test and evaluation and has occurred bilaterally both at AFCA and Rome Laboratory. Efforts to date include the integration of respective AFCA and Rome Laboratory indigenous HF E-mail systems at both agencies in support of true implementation of the Scope Command worldwide digital messaging HF network for Air Mobility Command (AMC).

- Rome Laboratory initiated a joint program, High Capacity Trunk Radio (HCTR), with the Space & Terrestrial Branch at US Army CECOM. This radio handles data rates of DS-1, DS-3, and OC-3c/STS-3c, using miniaturization so that all of the equipment can be contained in easily replaceable modules for use inside the Radio Access Point (RAP) shelter that is part of the Army's Area Common User System (ACUS). Interface between this radio and an existing Army phased array antenna (PAA) was designed.

- The Mini Transportable Communications Central (MTCC) Terminal was successfully delivered to the US Coast Guard (USCG) in early 1996. Since then the USCG has used the system in several drug interdiction operations as well as for security control (at the 1996 Olympic Games in Atlanta, GA), and search and rescue operations. USCG is looking to enhance the MTCC with a fiber optic link and other new functions. Its predecessor was used in search and rescue efforts in the aftermath of Mississippi flooding, Florida hurricanes, and California earthquakes, and was deployed to Haiti, Cuba, Guam, Alaska (various applications), and classified sites for drug interdiction operations.

- An F-16 ground testbed for operational situation awareness and targeting demonstrations has been developed which represents a Block 30 configuration aircraft capable

of simulating flight scenarios. Rome Laboratory is working with the Syracuse Air National Guard to modify Rome Laboratory's F-16 testbed to develop and demonstrate new technologies to affordably link AWACS, Joint STARS and real time intelligence data directly to the cockpit of the fighters. Information available in the AWACS will be available to the fighter pilot with the touch of a button. C^4I communications, sensor data processing and distribution technologies will be integrated to assess seamless communications/connectivity and directly distribute information to the fighter pilots in the cockpit. In the first demonstration, information from the AWACS will be sent directly to the fighters without the need to talk to the pilots. Initially the Syracuse Air National Guard will equip the F-16 with the Situational Awareness Data Link (SADL) equipment to directly link AWACS data to the cockpit.

- Rome Laboratory designed, developed, documented, tested, and delivered a laser mapping system for use by the Navy. The system provides an accurate computer-resident map of a target up to 25 feet in length with a quarter-inch resolution of the surface. The laser is guided by a personal computer which also collects and resolves the point data into a surface rendering of the object being mapped. A second version is being designed in-house which will be more portable and able to provide an analogous mapping capability for aircraft-sized targets.

- Rome Laboratory is working with DARPA to develop the CAD tools necessary for designing mixed technology systems composed of analog, digital and Micro-Electro-Mechanical devices. The current efforts are the first step to create a modeling and simulation environment for these true "systems on a chip." This effort will have a significant impact on the Air Forces vision for Air and Space Power for the 21st Century.

- Rome Laboratory is teaming with Lincoln Lab, CECOM, and NRL to support DARPA's new programs for battlefield communications connectivity with internet like services between ground and airborne warriors. This connectivity plan includes UAVs.

- Rome Laboratory is working with NSA on the Consolidated Computer Security Program to develop secure distributed systems, secure data management systems and design and verification of secure systems.

- Rome Laboratory is working with DARPA on the development of software technology to enable systems to envolve over extended life times. The Evolutionary Development of Complex Software (EDCS) program will develop the capability to allow new and legacy software systems to economically and easily evolve to accomodate changing technology and operating environments.

Project Reliance

Under Project Reliance, the Director, Defense Research and Engineering has continually enhanced the strategic planning process for Defense Science and Technology (S&T) program. This process has increased coordination, decreased duplication, and improved joint interoperability among the services. The annual Technology Area Review and Assessments (TARAs) are a key part of the process, chaired by the Director, which assure a comprehensive, independent review of the S&T program.

Rome Laboratory is an active participant in the joint Defense S&T Reliance planning process, chairing several panels/subpanels. The C4I program is coordinated across the services and documented in the Defense Technology Area Plan (DTAP).

Two Rome Laboratory personnel serve as principals on the Information Systems and Technology Panel. In addition Rome Laboratory chairs the Seamless Communications subpanel under the Information Systems and Technology DTAP area.

Rome Laboratory participates in the Computing and Software Technology subpanel under the Information Systems and Technology area with Army and Navy service counterparts and DARPA. Together with DARPA, Rome Laboratory joints sponsors the new Evolutionary Design of Complex Systems (EDCS) initiative under this subpanel. The goal of this initiative is to develop new technology enabling long-lived software to efficiently evolve in response to changes in requirements and operating environments.

Rome Laboratory also particpates in the Decision Making subpanel under the Information Systems and Technology area with the Army, Navy and DARPA. Rome Laboratory jointly sponsors (with DARPA) the Knowledge-based Planning and Scheduling Initiative (ARPI). This initiatve provides new generation high performance planning and scheduling technology in support of the JFACC and Advanced Logistics programs, among others.

The Communications Program has been coordinated both within the Air Force and the DOD Project Reliance. A joint Communications Coordinating Plan as been prepared in conjunction with Wright and Phillips Laboratory. This plan has been integrated into the Seamless Communications portion of the Defense Technology Area Plan in which the entire Air Force Program is aligned with the Defense Technology Objectives. Now, for the first time, a single program of work, that encompasses Space, Air and Ground Communications R&D can be found in a single coordinated plan.

Under a Defense Science & Technology Reliance agreement, the Air Force SPEAKeasy Program Office serves as the DoD Executive Agent of the SPEAKeasy Program, and col-

laborates with the other Joint Program Partners including: the Defense Advanced Research Projects Agency (DARPA/ISO), US Army CECOM, and US Navy NCCOSE RDT&E Division.

Under the Defense Science & Technology Reliance Program, a Tri-Service advanced networking testbed is being established that will electronically interconnect the Service labs and some limited number of operational users. This testbed will support Tri-Service research in high speed networking as well as the distributed processing and decision aids.

Rome Laboratory and the Army CECOM are pursuing a joint program, High Capacity Trunk Radio (HCTR). This radio can be contained in easily replaceable modules for use inside the Radio Access Point (RAP) shelter that is part of the Army's Area Common User System (ACUS). Interface between this radio and an existing Army phased array antenna (PAA) has been designed.

Rome Lab, as a member of the Information Management and Distribution subpanel is actively involved with both ARL and NRaD in the development of Distributed Information Systems techology. As part of this effort a Tri Service Distributed Systems testbed has been established with clusters at RL, NRaD and ARL. This testbed is used to support development and evaluation of new capabilities and mechanisms for replication, time critical distribued processing, and user interfaces.

Rome Laboratory participates in a number of Reliance efforts in the Electronic Devices subpanel of the Sensors and Electronics DTAP area. Reliability Science R&D efforts in the area of microwave solid state components, microwave photonics, analog opto-electronic integrated circuits, and high speed lasers are being pursued. Rome Laboratory has joint programs with AF/Wright Laboratory, Naval Research Laboratory, and the Army Research Laboratory. Efforts are being accomplished jointly with Naval Research Laboratory, Naval Surface Warfare Center, Army Research Laboratory and AF/Wright Laboratory in the areas of Gallium Arsenide (GaAs) MIMIC and high power HBTs, multichip modules (MCMs), and plastic encapsulated microelectronics This work is applicable to all communication and radar systems.

Rome Laboratory also participates as a member of the "Science and Technology Reliance Assessment for Modeling and Simulation Technology (STRAMST) tri-Service Ad Hoc working Group." This initiative will establish a service-wide coordinated program in Modeling and Simulation.

Rome Laboratory is a member of the RADAR Sensors Panel Planning Team. We have the lead responsibility for a Defense Technology Objective (DTO) entitled SE.03.01ANF Enhanced Moving Target Detection Development. Through this DTO we are impacting and leveraging Army and Navy sensor upgrades through the development of Space Time Adaptive Processing (STAP) for airborne applications in Navy E-2C (Hawkeye) and Army Tactical UAV programs.

Rome Laboratory works with Naval Research Laboratory (NRL), Naval Command and Control and Ocean Surveillance Center's Research and Development Division (NRaD), and Army CECOM under Project Reliance on speech related identification and transformation technologies.

Rome Laboratory in conjunction with ASC, five logistic centers, NAWC and Army is supporting ABBET, a set of software interface standards for the test domain to facilitate the transition of test information and implementation of automated tests. These software standards are defined to support software component portability, reusability, exchangeability, and interoperability, and to serve as targets for test-related software development tools. ABBET is to be developed under the auspices of the IEEE through the Standards Coordinating Committee (SCC) 20.

Rome Laboratory's photonics program is very closely coupled with DARPA, particularly in the areas of photonic systems, devices and opto-electronic integrated circuits. Two large DARPA sponsored photonics development programs, Optical Micronets and VLSI Photonics, have the potential to significantly impact high performance computer interconnect fabric, and to alter the way future military and commercial information processing systems are designed and built. Rome Laboratory participates in a significant fraction of these multidimensional programs through contractual and inhouse efforts. One of Rome Laboratory's staff members is assigned to DARPA part time to support their photonics program.

Rome Laboratory participates in the Tri-Service Data Fusion Group which has representives from Rome Laboratory, AF/Wright Laboratory, US Army CECOM, Naval Command and Control and Ocean Surveillance Center's Research and Development Division (NRaD), the Office of Naval Research-Europe, the National Security Agency (NSA), industry and academia. The Data Fusion Group serves as a vehicle for experts in the data fusion community to work jointly in defining a common framework and understanding of the technology and share information and technology regarding each.

Changes From Last Year

The primary changes in the C^4I S&T program over the past year are:

- Rome Laboratory reprioritized its C^4I S&T program to place added emphasis on technology applicable to New World Vistas capabilities plus the AFMC/ST emphasis area of Information Dominance. The Rome Labotatory is focused on a 21st Century C^4I Global Engagement vision

encompassing Global Awareness, Dynamic Planning and Execution, and Global Information Exchange.

- Initiated a basic research program to develop a Global Awareness Virtual Testbed in response to the New World Vistas call for new concepts to cope with the world of the 21st Century. This testbed will permit the evaluation of a wide range of global awareness technologies. Emphasis will be placed on development of system-wide metrics which permit measurement of information gains for sensor, communications, and fusion processing functions. Technologies advanced will include, but are not limited to global sensor networks, multi-level fusion, decision aids and information displays.

- Rome Laboratory and Armstrong Laboratory are working together on a New World Vistas effort aimed at addressing AIA's need for a Decision Support System (DSS). Rome Laboratory is performing basic research in Natural Language Understanding (NLU), with emphasis on complex event extraction. Armstrong Laboratory is performing basic research in Advanced Information Visualization, with emphasis on cognitive techniques for conceptualizing complex events, temporal and spatial patterns, and decision-making alternatives.

- The Reliability Sciences Thrust was reduced as part of the FY98 S&T POM strategy resulting in elimination or reduction of several reliability technology programs and DoD unique research facilities.

SUMMARY

The C4I S&T program is crucial to Global Engagement. Rome Laboratory C4I technologies will revolutionize modern combat. The technical foundation of the Rome Laboratory initiative is the ability to sense, analyze, distribute, and use huge amounts of information to support worldwide operations. Figure 6 provides a mapping of the C4I TAP Thrusts to the Attributes of Global Engagement as we look forward to the 21st Centuary Air Force C4I vision.

RL TAP Thrusts	Global Awareness	Dynamic Planning & Execution	Global Information Exchange
Surveillance	●		
Communications			●
Command & Control		●	
Intelligence	●	●	●
Signal Processing	●	●	●
Computer Science & Technology	●	●	●
Electromagnetic Technology	●	●	●
Photonics	●	●	●
Reliability Sciences	●	●	●

Figure 6. *Attributes of Global Awareness*

Mission payoff includes both immediate improvements for today's inventory of C4I systems and the technological basis for future systems. At the same time, this world class technology is significantly impacting the commercial market through technology transfer. The program described in this TAP results from a rigorous investment strategy process which balances the needs of all customers with available resources.

Each of the TAPs thrusts are discussed in the sections that follow. A macro-graphic roadmap of the thrust's technology program is included for each thrust.

THRUST SURVEILLANCE

User Needs

The Air Force needs to improve the performance and reduce the cost of Air Force surveillance systems. Technologies being developed to meet these needs include: advanced cooperative/noncooperative bistatics; space-time adaptive processing; sensor/data fusion; advanced array antennas; and Over-The-Horizon Radar.

- The **Surveillance and Reconnaissance Mission Area Plan (MAP)** identifies responsive tasking and the ability to detect and track Critical Mobile Targets as major deficiencies. Other severe C4I limitations include detection of low altitude, low observable threats and high confidence hostile target identification of wide area threats according to the **Air Combat Command (ACC) Theater Battle Management, Reconnaissance and Surveillance, and Theater Missile Defense MAPs.**

- The **Joint Mission Needs Statement for Theater Missile Defense** states a requirement for "... a robust C4I and surveillance capability unique to Theater Missile characteristics." The radar cross section and low altitude of cruise missiles makes them very difficult to detect with fielded sensors due to clutter, jamming, and "hot clutter." "Hot clutter" is a terrain scattered interference signal. Developing the ability to reject "hot clutter" is viewed as a major problem by DARPA and the Services.

- USACOM, USSOUTHCOM, and NORAD have identified Over-The-Horizon Radar as a main surveillance asset in the counterdrug mission. This has led to two new Over-The-Horizon Radars being installed in the relatively near future, and has fostered an effective and close working relationship between the operational and technical Over-The-Horizon Radar community. The **ACC Strategic Defense MAP** identified Over-The-Horizon radar as a solution for current C4I system deficiencies.

- The **Air Force Special Operations Command's** need for real-time situation awareness and threat updates is specified in their **Weapons System Roadmap.** It also emphasizes the need for sensor covertness and cueing using offboard sensors.

Goals

- Develop Space-Time Adaptive Processing (STAP) techniques for improved detection of low observable targets in presence of serve clutter and jamming.

- Develop bistatic sensor technology and concepts to reduce system cost and to improve sensor survivability and covertness.

- Develop multi-platform sensor data fusion cueing/correlation concepts using offboard data to improve sensor efficiency, hostile target identification, and real-time situation awareness.

- Develop and transition technology in Over-The-Horizon Radar for counterdrug surveillance.

- Develop and transition concealed Weapon Detection and through the wall surveillance advanced sensor fusion techniques which combine various sensor outputs to identify personnel activities.

Major Accomplishments

- Integrated Electronic Support Measures (ESM)/Bistatic Radar technology was demonstrated on a major reconnaissance platform during operator evaluations of its operational capabilities. Application of this technology will give the platform a unique capability to unobtrusively provide situational awareness to battlefield commanders. In addition, the Airborne Multimode Bistatic (AMBIS) testbed's unique integrated ESM/Bistatic capabilities were used for a joint Rome Lab/Naval Research Lab "open ocean" application.

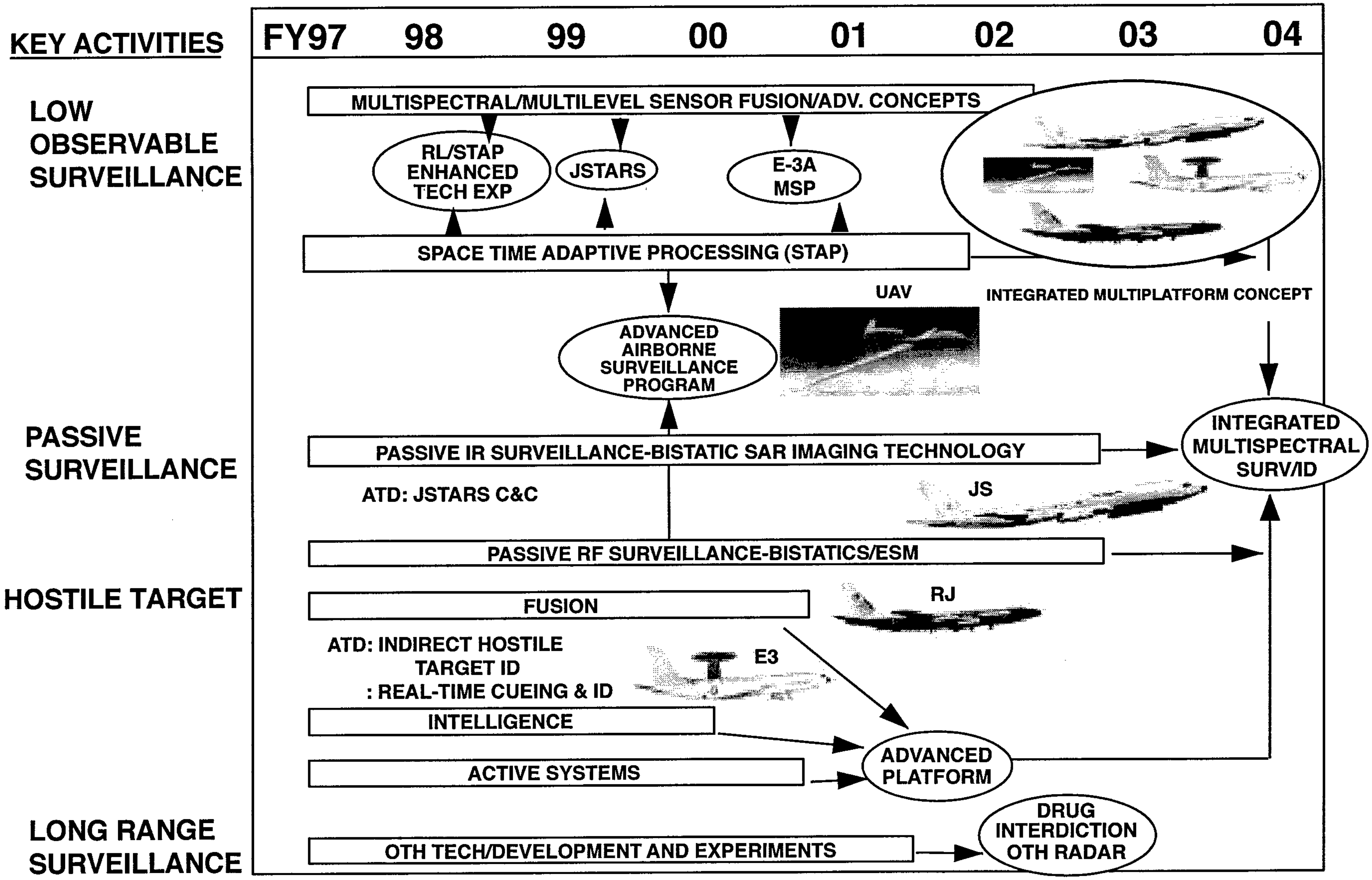
- The High Performance Computing for Joint STARS Cueing and Correlation (HJC&C) and Offboard Augmented Theater Surveillance (OBATS) Advanced Technology Demonstration's (ATD's) testbed capabilities were integrated and demonstrated for scenarios applicable to the Joint STARS mission requirements. This capability is the first real-time demonstration of the application of advanced distributed fusion and multisensor resource management techniques to locate, identify and prioritize Tactical-Erector-Launchers (TELs) and other strategic/tactical ground targets.

- The Track and ID Fusion effort under the Rome Laboratory Hostile Target Identification program demonstrated the fusion of data from surveillance, reconnaissance, and intelligence sensors to provide positive and timely identification of air targets, and enhanced situational awareness. Demonstrations and evaluations were conducted by personnel from the AWACS Joint Test Force using E-3 AWACS and TADIL-J data collected during ASCIET-96.

Changes From Last Year

Funding and manpower reductions have continued to cause delays in the execution of this thrust.

SURVEILLANCE



MILESTONES

1998:

- Complete interface of Computational Electromagnetic (CEM) codes to Rome Laboratory's Space-Time Adaptive Processing Algorithm Development tool.
- Initiate real-time airborne demonstration of multiplatform, all source advanced fusion and correlation capability for the detection and tracking of time-critical ground targets.
- Complete 64-channel ground-based testbed evaluations of critical antenna matching/calibration issues and begin bistatic critical issues testing.
- Initiate development and demonstration of advanced measures of performance/measures of effectiveness algorithms for integrated knowledge-based fusion concepts.

1999:

- Conduct Advanced Airborne Surveillance Program Development
- Conduct development of advanced measures of performance/measures of effectiveness algorithms and initiate transition to laboratory real-time testbed.
- Conduct bistatic critical issue technology tests using 64 channel ground based testbed.
- Complete RL/STAP Enhancements for SAR applications to JSTARS.

THRUST

COMMUNICATIONS

User Needs

This thrust supports the Air Force's need to instantaneously access information by providing global communications for the rapid application of air power. Communications systems must provide assured connectivity for timely, reliable, responsive, and affordable transfer of information.

The user needs addressed in this thrust have been derived from the following documented requirements:

- **ACC Theater Battle Management Mission Area Plan (MAP)**
- **Air Mobility Command Airlift MAP**
- **Air Force Communications Agency Communications Squadron 2000**
- **Air Force Communications Agency Superhighway 2000**
- **CAF Mission Need Statement for Counter-Drug Air-to-Air Detection and Monitoring**
- **Defense Planning Guidance (DPG) for MILSATCOM**
- **AF Master Deficiency List for MAJCOMS**

Goals

- Develop and demonstrate advanced communications technologies required to link national command authorities and sources to Air Force components of a Joint Task Force, regardless of location. Special emphasis is placed on air-to-space/ground connectivity and robust, protected forms of connectivity that go beyond what the commercial market can provide.
- Technology developments include:

•• Modular, programmable radios that are easily maintained, interoperable, robust and multi-level secure.

•• Robust networking systems to provide automatic network restoration and the automatic flow of information at multiple levels of security.

•• Seamless information handling capabilities to achieve an integrated network environment of distributed systems using lighter, deployable communications.

•• Lightweight, miniature, low input power RF subsystems to reduce the weight of SHF/EHF spacecraft communications payloads by 50 percent for launch on the Medium Launch Vehicle.

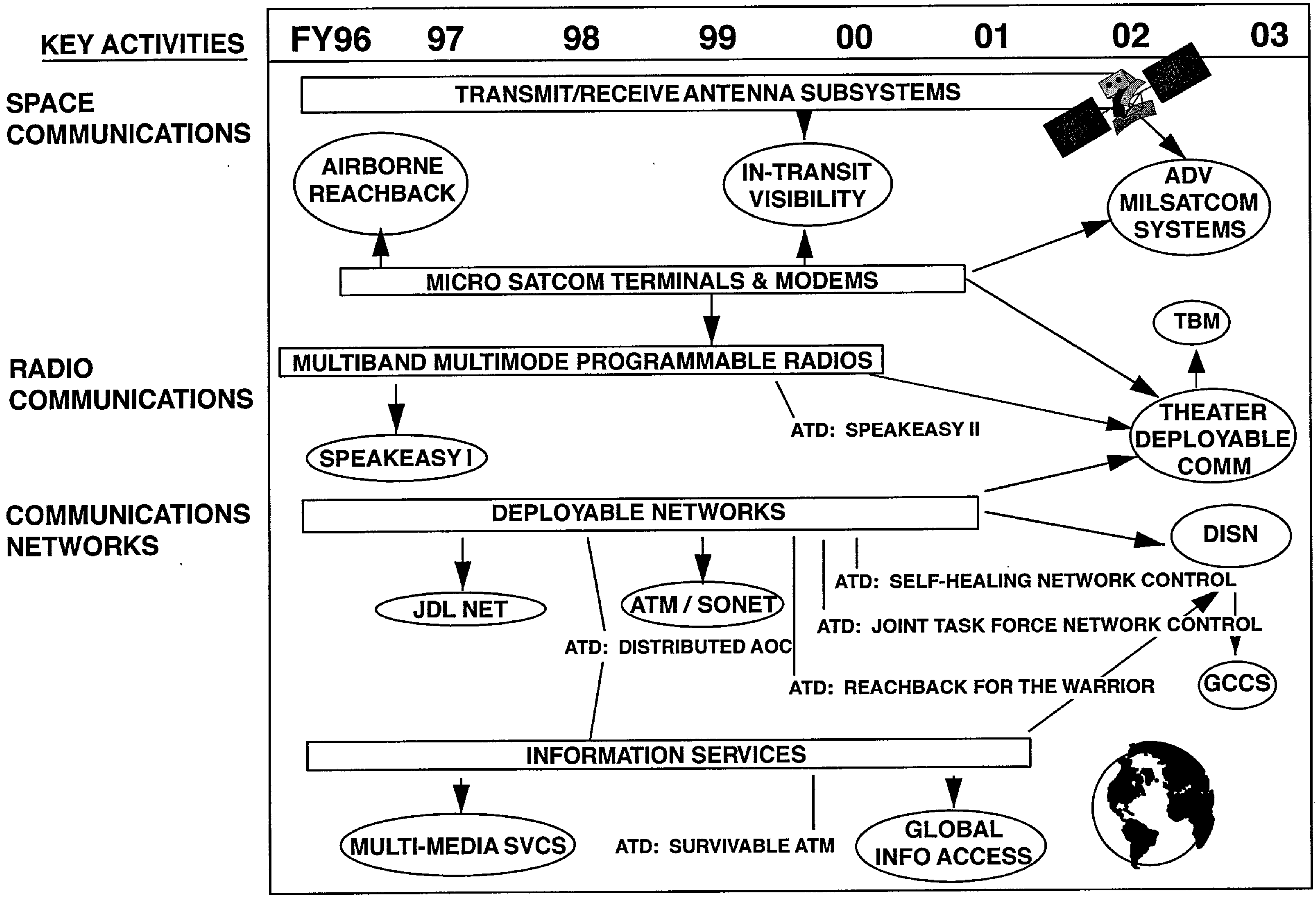
•• Small ground/air transportable communications equipment suite with integrated workstation housed in a ruggedized shelter, configured to provide operators with secure simultaneous multiband, multifunction radio communications.

•• Exploitation of secure digital messaging over HF and UHF Satcom to airborne platforms for e-mail, file transfer, video images and high bandwidth applications.

Major Accomplishments

- Demonstrated a two-channel SPEAKeasy radio at TF-XXI-AWE at Ft Irwin CA.
- Demonstrated Multimedia Wireless Extension (MWE) Modems at Global Apache 97 and JWID.
- Demonstrated a secure carry-on HF/UHF radio suite for connectivity to aircraft for low data rate e-mail and telemedicine video imagery.
- Demonstrations of secure data Reach-back communications services for aircraft connectivity via HF/UHF satellite links at Global Apache 97.
- Flip-Wave bandwidth efficient spread spectrum communications waveform developed and rapid prototyped as a function in the Smart Radio design. (Patent Pending)
- Demonstrated ATM Management and Control Application Programmer Interfaces (API) enabling cooperation between distributed multimedia computing, distributed ATM service management, and distributed ATM network control applications running on a CORBA platform over an ATM network.
- Demonstrated the world's highest power 44 GHz solid state MMIC power amplifier with >4.5 watts of output power, and 20 percent Power Added Efficiency (PAE).
- Demonstrated a lightweight 44 GHz multiple beam electronically steered receive antenna with simultaneous eight beam capability using the world's first space qualifiable InP MMIC.
- Demonstrated nulls greater than 50 dB for a MMIC EHF antenna.
- Demonstrated Video on Demand and multimedia traffic over ATM for real-time AOC/FOL Battle Damage Assessment.
- Transitioned Network Management capabilities for Secure, Survivable Communications Network (SSCN) to DARPA/DISA JPO and DISN LES.
- Demonstrated real-time in-flight update of patient vital statistics for AF Aeromedical Evacuation mission.

COMMUNICATIONS



- Completed development of virtual private network (VPN) architecture enabling transparent interconnection and control of private broadband networks over public broadband infrastructure.
- Emulated Quality of Service, Virtual Path, and Priority Network Management capabilities for DoD network Control using high performance emulation platform with real-time 3D visualization.

CHANGES FROM LAST YEAR

New DARPA sponsored programs for Warfighter Internet and Airborne Communications Node to provide enhanced communications connectivity to battlefield forces including internet-like services between ground and airborne warriors via a UAV.

MILESTONES

1998:

- Demonstrate new RF MEMS component technology. Focus this technology on solving cosite interference problems for UAVs by developing MEMS based multiband tuners.
- Demonstrate a 44 GHz airborne antenna capable of medium data rates.
- Demonstrate a multiple beam, electronically steered, 20 GHz transmit phased array based on GaAlAs PHEMT MMIC and InP HBTs.
- Demonstrate narrowband and wideband, secure voice & data, internetworking, voice bridges and openness of the SPEAKeasy system.
- Demonstrate MWE high data rate trunk capability for military, government, and civilian users
- High Capacity Trunk Radio (HCTR) - Receive delivery of first proof-of-concept (POC) units for: self aligning antenna (SAA), RF head (inside shelter mount), RF head (tower mount), and transceiver.
- Complete Traffic Flow Visualization and Control Program.
- Demonstrate over-the-air Flip Wave Packet with GPS synchronization and rapid acquisition.
- Demonstrate FPGA based interference excision operating in conjunction with the Smart Radio Spectral Flatness decision algorithm and selected excision techniques.
- Demonstrate Fiber Optic Wavelength Division Multiplexing (WDM) for Integrated analog voice, video and digital data (ATM, Ethernet) on a single fiber for tactical C2 applications.
- Demonstrate integration of ATM Management and Control APIs, peer-to-peer network management system, and User Security Services.

1999:

- Demonstrate full functionality of SPEAKeasy in narrow and wideband, secure voice & data modes; including Link-16 compatibility and a potential gateway function between an Army digitization waveform and Link-16 situation awareness data links.
- Demonstrate multi-rate adaptive Smart Radio system incorporating advanced coding techniques.
- Demonstrate an advanced communications engine, developed under DARPA TRP, to support multiband multimode radio functions.
- Conduct joint CECOM/RL demonstration of HCTR.
- Demonstrate an airborne communications node onboard an Unmanned Aerial Vehicle, capable of networking multiple disparate radios.
- Demonstrate low cost phased array manufacturing technology with a 256 element 20 GHz receive MILSTAR/GBS array.
- Demonstrate a Survivable ATM switch for noisy low data rate communications links for integration into ESC's TBMCS/TDC Program.

2000:

- Demonstrate initial capability of Smart Radio system, including advanced network and link level capabilities.
- Demonstrate and Integrate Multi-Level Secure Network Management System for ESC TDC, DISN Networks.
- Transition Fiber Optical WDM Communications for TBMCS/TDC.

2001:

- Demonstrate a multilevel secure ATM switch for theater area applications TBMCS/TDC, DISN.

2002 :

- Demonstrate Active Networks for rapid node deployment and network self healing in a tactical environment.

THRUST

COMMAND & CONTROL

USER NEEDS

The changing world picture has dramatic implications for the Command and Control (C2) capabilities of U.S. forces. In implementing the Air Force Global Engagement model, we still address the issues associated with the new operational environment — joint operations, new force structures, force draw down, loss of forward basing, and emphasis on time critical fixed and mobile targets. Overcoming the downside of these issues demands continued development of flexible, modular, and interoperable C2 to support force multiplication, rapid power projection of joint or coalition forces. In addition we be able to support extensive reachback capability, real time operations in both Regional Crisis' and Operations Other Than War (OOTW).

The context for such C2 has been articulated by the Defense Planning Guidance for 1995-1999, the Joint Publication 3-56.1"C2 for Joint Air Operations"concept and by the Air Staff through both the Air Force Vision 21. Its implementation is further articulated in the the Global Command and Control System (GCCS). Technology implications have been developed under the USAF Scientific Advisory Board New World Vistas Study, the Defense Science Board Information Architecture for the Battlefield and the DDR&E Advanced Battlefield Information System(ABIS) study report. All emphasize priority improvements in information technology for the dynamic battlefield environment. These priorities have been promulgated downward and articulated through the following documented user needs:

- **AF Space Command/ACC Air and Space Power MAP and TBM General Officers Steering Group (TBM/GOSG) Operational Goals** include: Reducing the Planning Cycle, Improving Joint Interoperability,and Establishing a common picture of the battlefield.
- **Theater Battle management Core System(TBMCS)** requirements state the need for automated planning and decision support tools to plan, direct, control, execute, report and replan the air mission. Interoperability with other TBM, Service and Allied automated systems for joint and combined operations is also a key need.
- Joint Staff Guidance through the **Air Task Order(ATO) Interoperability Working Group** identifies the need to develop, analyze, and execute the ATO for joint operations in a timely and accurate manner within a constantly changing battlefield.

GOALS

- Support "come as you are" warfighting with "anywhere, anytime information based support." The focus is on the Commander Joint Task Force (CJTF), Joint Force Air Component Commander (JFACC), the Area Air Defense Commander(AADC) and the Joint Air Operations Center (JAOC) with horizontal, joint service interoperability.

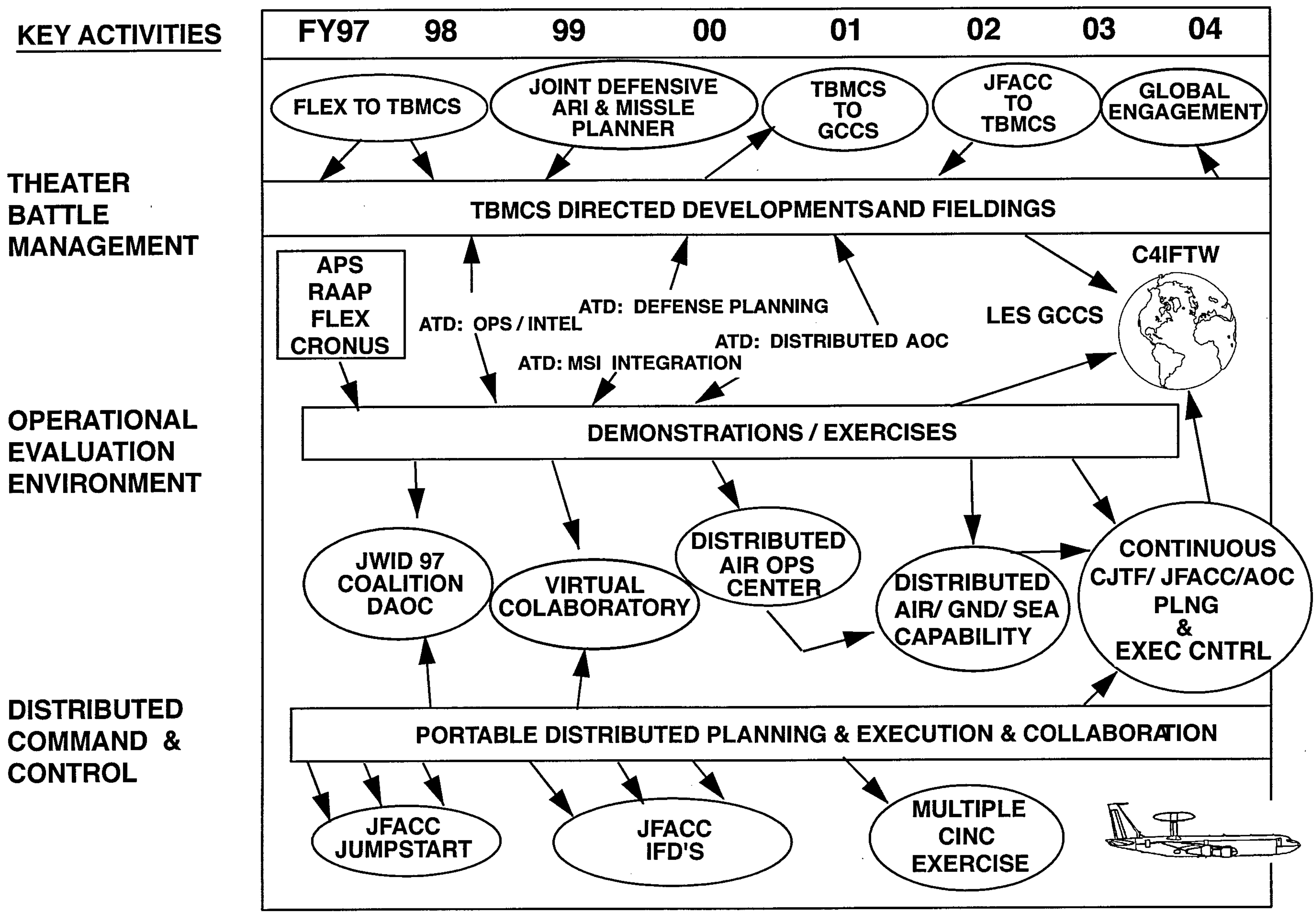
To support this goal, the thrust has been structured with activities of both a near-term focus, and a longer term vision which strives to harness new intelligent information technologies for application to the objectives of AF Vision 21. Spanning these two activities are the Service Battle Labs, which support Joint and/or Air Force only tests and demonstrations. The thrust can be effectively separated into the following four measures of effectiveness/payoffs:

- •• Focus near-term investment on information technology that will support Joint Air Operations Center operational requirements for AF/Joint automated decision support tools for reduced decision cycles.
- •• Develop next generation intelligent information services which will support a globally dispersed, joint and coalition capability which provides single thread collaborative planning from the CINC to the units, real time execution monitoring and replanning, integration of all information sources, reachback, and traceability from guidance to mission execution.
- •• Demonstrate efficient and effective acquisition concepts (e.g.. rapid prototyping) and technology transition strategies (e.g. user/developer testbeds) for software systems.
- •• Demonstrate operational utility in regular military exercises involving unified commands and their component services, and in Joint Warrior Interoperability Demonstrations where evolving technologies can be seen and evaluated by the user community.

MAJOR ACCOMPLISHMENTS

- The FLEX program has been modified to incorporate the new Joint 98ATO format, and has been designated a Joint Module for use by all services TBMCS sites.
- The Defensive Planning/Execution program has been designated as the Joint Defensive Planner (JDP) by the Air Operations Working Group which represents all of the services.
- The Ops/Intel Integration (OII) ATD has been completed and transition opportunities are now being investigated.
- A collaborative planning demonstration was executed during Joint Warrior Interoperability Demonstration

COMMAND AND CONTROL



(JWID) 97. It concentrated on air operations planning in a coalition environment, linking ATO planning cells at the US AOC, with coalition planning cells through a secure guard, These were located at Barksdale AFB. and linked to the Canadian planning center at Winnepeg.

- The JUMPSTART phase of the JFACC program was successfully completed with a series of demonstrations at the AF Air Warfare Center at Hurlburt Field. It provided a feasibility demonstration of the capability to support objectives based air operations planning based on the concept of a common plan representation and an integrated toolset.
- During the Global Apache 97 exercise, the FLEX system was used to monitor and manage execution of the ATO in the AOC.
- The Distributed Air Operations Center (DAOC) ATD was extended by incorporation of enhanced information handling capabilities and was incorporated into the JFACC JUMPSTART effort. The final DAOC ATD demonstration was held in Jun 97.

Changes From Last Year

- The development phase of the JFACC program was initiated with the initiation of ten contractual efforts. The program will be executed in close coordination with both the AF and Navy battle labs. The first demonstration will occur in 1QFY98.
- The OII phase II program was eliminated with several of the tasks being covered by other programs.

Milestones

Strong relationships continue with the Defense Advanced Research Projects Agency (DARPA), and the Air Force TBMCS programs. These partnerships sponsor work in both the near-term TBM and longer term Distributed C2 activities.

The Thrust provides these programs with a transition path into the TBMCS directed operational architecture enhancement process as well as a transition path to GCCS.

Major milestones include:

1998:

- Transition FLEX to TBMCS V1.0 to include the new 98ATO, a port to the Navy standard computer for shipboard use, and development to meet the DII COE V3.0 Level 5 requirements
- Continue to support JWID, ESC/CUBE, Global Apache and other similar annual exercises.
- Implement the JFACC user/developer testbed with nodes at Rome Lab, NRAD, AF Battle Lab, Navy Battle Lab and selected contractor facilities.
- JFACC Integrated Feasibility Demonstration One, to demonstration initial objectives based planning capability including ISR , Force Application and Force Support planners.
- Provide JDP version to coincide with TBMCS version 1.0.
- Transition DAOC to TBMCS.

1999:

- Provide FLEX V2.0 for fielding in TBMCS.
- Demonstrate Initial Functional Capability for the "JFACC After Next" including Workflow Management, Strategy Development and Objectives System Analysis tool.
- Complete JDPATD and transition to TBMCS

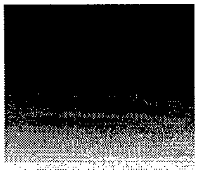
2000:

- Provide JDP version to coincide with TBMCS version 2.0.
- Prototype demonstration of JFACC capability in a high assurance information architecture.
- Transition elements of the JFACC after next capability to TBMCS/GCCS.
- Integrate JDP as a planning tool in the JFACC palnning tool suite.

2001:

- Provide JDP version to coincide with TBMCS version 3.0.
- Demonstrate continuous, real time planning, execution monitoring and replanning capabilities to support distributed CJTF/JFACC as part of JFACC Battle Management Initiative.

THRUST



INTELLIGENCE

User Needs

The Intelligence community must provide timely and accurate information in a secure and reliable manner to enhance air and space superiority, precision employment, global mobility and information dominance.

The **Air Combat Command (ACC) Theater Battle Management MAP and Reconnaissance and Surveillance MAP** requires timely battle damage assessment with the results being inserted into the Air Tasking Order.

The **Department of Defense Intelligence Information System (DoDIIS)** needs to monitor threatening situations, pass correlated multi-media intelligence products from Headquarters to Units, and provide updates on a timely basis to support regional conflicts.

The **Air Intelligence Agency (AIA)** require data processing techniques to manage information warfare, extract tactical information from communications, develop tactical deception plans, model foreign threats and track the proliferation of weapons of mass destruction.

The **Intelligence Community** must develop advanced information processing and storage systems to ensure that data collected is stored, organized, analyzed and disseminated to decision makers and warfighters at all levels. Air Intelligence units need to colloborate with each other in real-time, providing time sensitive information to operations.

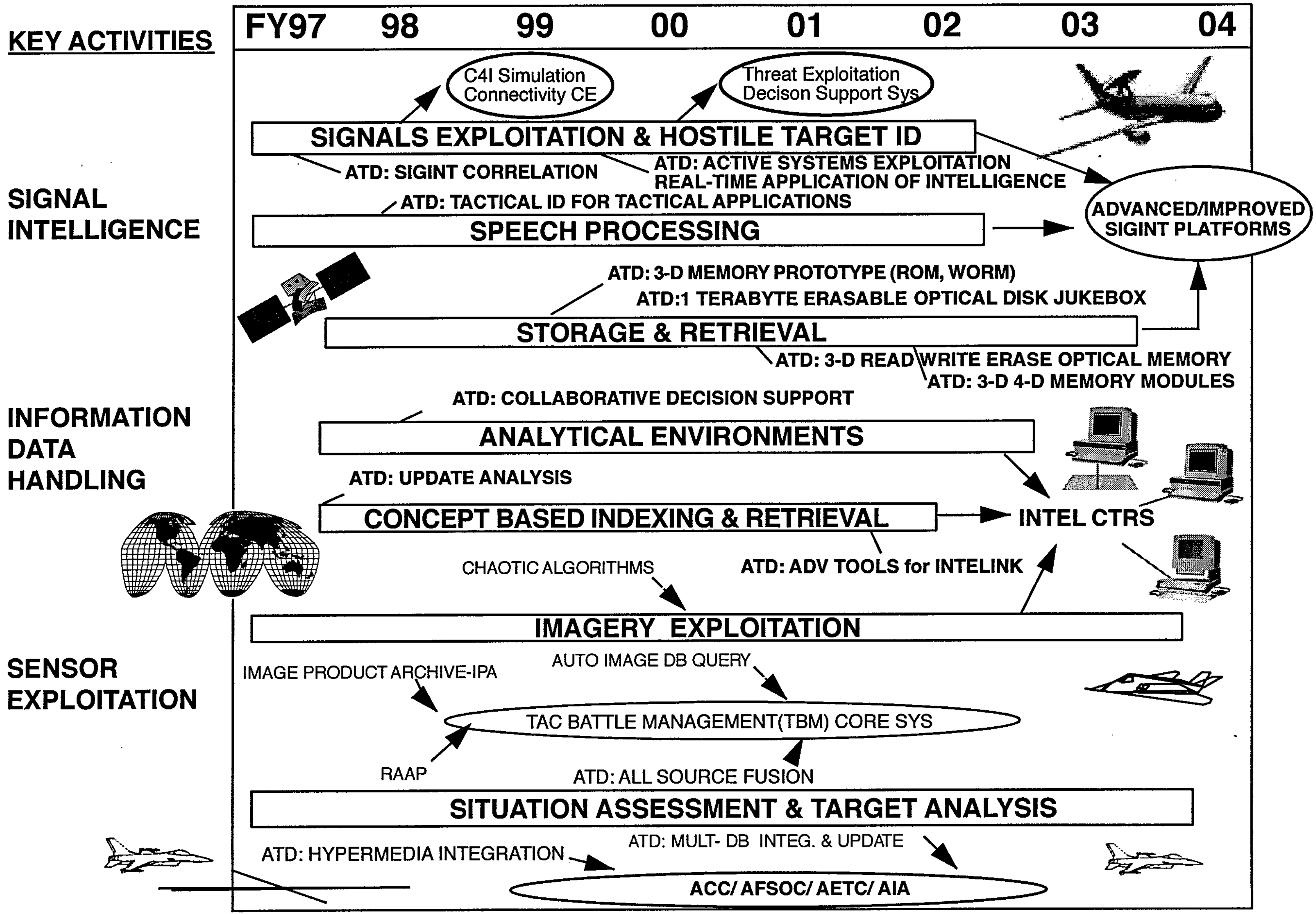
Goals

- All thrust investments will support Global Engagement, USAF Core Competencies, and New World Vistas.
- Develop technologies for insertion into the C3I community and pursue technology transfer to commercial markets.
- Develop enabling information processing technologies responsive to operational deficiencies by improving timeliness, reliability, and accessibility of information to the warfighter.
- Advanced signal exploitation techniques will be developed to respond to operational deficiencies by improving timeliness of intelligence to the warfighter.
- Provide a secure and reliable method of transmitting intelligence imagery to the warfighter using available communication systems.
- A major goal of this thrust is to develop a new class of non-mechanical memory systems. All memory operations will be performed optically without the limitations of rotating media.

Major Accomplishments

- As a result of AFSOC testing, enhancements were made to the Deployable Optical Jukebox (DOJ) for improved performance and lower acquisition cost.
- A 3-D optical memory was fabricated which illustrates the principle of 2-photon absorption.
- Completed and installed Track and ID fusion algorithms to process E-3 AWACS and TADIL-J data for the positive, long range identification of hostile airborne targets.
- Demonstrate for AIA a four channel audio sorting capability by speaker and language.
- Rome Laboratory and Armstrong Laboratory are working together on a New World Vistas effort aimed at addressing AIA's need for a Decision Support System (DSS).
- Rome Laboratory actively participates in the TIPSTER Text Program, an inter-agency program managed by DARPA, NSA, and CIA.
- Demonstated and delivered natural language processing software to HQ USSOUTHCOM to extract named entities from free text message traffic.
- Completed development of a prototype system for the retrieval of imagery by content.
- Developed and demonstrated a prototype, data extraction tool that uses shallow natural language understanding techniques to automatically populate databases.
- Developed the Consolidated Application Server, a scalable system integrating several intelligence applications; RAAP, DAWS, MIDB, 5D, and IPA. This effort has received a great deal of attention and interest from the user community due to its significant potential to reduce operations, maintenance, and logistics costs and its deployability characteristics.
- Developed and implemented an image ciphering and hiding algorithm based on Chaos Theory that provides an inexpensive and secure method of transmitting intelligence data over any digital communication system. This algorithm enciphers data at several orders of magnitudes faster than existing techniques. Patent rights for this algorithm have been applied for.
- Interim delivery of HyperTech hypermedia environment software was made to Rome Laboratory's Image Exploitation 2000 (IE 2000) test bed.
- Establishment of Rapid Applications of Air Power/Joint Targeting Toolkit (RAAP/JTT V2.0.3) as baseline standard for the Joint (non-CIS/TBM) Targeting

INTELLIGENCE



Community.

- Two secure communication networks, Leading Edge Services and SIPRNET, were integrated into the Image Exploitation 2000 Facility.

- The IE 2000 Distributed Architecture project is a first step toward the implementation of image processing, archiving, and retrieval functions utilizing Common Object Request Broker Architecture (CORBA) technology. This technology specifies a system which provides interoperability between software objects in a heterogeneous, distributed environment and in a way transparent to the programmer and the user.

Changes From Last Year

Two New World Vista efforts were initiated this year.

Milestones

1998:

- A 3-D Optical Read Only Memory (ROM) device that will verify massively parallel terabit capacity, gigabit throughput rate, and nanosecond access time will be delivered for Beta testing.

- A one Terabyte Erasable Optical Disk Jukebox will be delivered and integrated at the 480th Intelligence Group, AIA.

- Design and implement the physical infrastructure for the New World Vistas' Global Awareness Virtual Testbed.

- Continue improvement of intelligence data handling database interoperability and the ops/intel functional interface by adding semantic analysis functionality to automated, heterogeneous database access and update capabilities.

- Demonstrate a speaker identification capability to track speakers on cellular phones and frequency hop radios.

- Rome Laboratory will continue it's long-standing participation in the Advanced Information Processing & Analysis Steering Group (AIPASG).

1999:

- A 3-D Optical Write Once, Read Many (WORM) times, memory device that will verify massively parallel terabit capacity, gigabit throughput rate, and nanosecond access time will be delivered and integrated into the AFINTNET program.

- Develop Global Awareness Virtual Testbed Build 1.

- Continue development of advanced, automated techniques to ensure information currency, accuracy, and availability in a heterogeneous, multi-service, database environment.

- Support General Defense Intelligence Program (GDIP) consolidation of smaller component migration database and application systems to work with larger component systems such as Modernization Integrated Database (MIDB).

2000:

- A 3-D Optical Read, Write, Erase memory device will be fabricated and used as the foundation of an advanced development model.

- A pre-prototype four-dimensional, DNA optical memory device representing a paradigm change in memory capabilities will be delivered for in-house testing.

- Develop Global Awareness Virtual Testbed 2; resulting in interlab physical and functional connectivity. Exercise Global Awareness Virtual Testbed.

- The Target ID for Tactical Applications ATD will provide the automatic recognition of targets based on audio acoustics.

- Extend automated learning algorithms to perform deeper event-type data extraction.

THRUST

SIGNAL PROCESSING

User Needs

Signal processing technology turns raw data into the higher level real-time information that feeds every aspect of the C4I mission including:

- The **Air Combat Command (ACC) Tactical Battle Management Mission Area Plan (MAP)** identifies a mission need for E-3 to include programmable adaptive signal processors as key components to significantly improve radar signal processing.
- The **Strategic Attack Interdiction MAP** requires real-time target location versus small/mobile targets.
- The **Space Control MAP** includes multiple requirements for high throughput processors and improved surveillance algorithms.
- The **ACC Strategic Defense MAP** requires improved real time processing capability, real-time displays, and adaptive signal processing for Beyond-Line-of-Sight communications.
- The **Intelligence Functional Area Plan and Surveillance and Reconnaissance MAP** calls for continued advances in speech and audio signal processing.

Goals

- Advance signal processing technology, exploiting commercial technology whenever possible and rapid transition of the resultant advanced technology to military and commercial applications.
- Drive down the cost and complexity of C4I signal processing systems, improving throughput by a factor of 100 every seven years.
- Rapidly field the latest signal processing techniques for surveillance, communications, and intelligence.
- Spin on and spin off technology transfers, maximizing competition and minimizing cost by reusing commercial hardware and software.
- Reduce system hardware complexity by shrinking racks of equipment with hundreds of part types down to single board solutions, simplifying logistics and aiding two level maintenance.
- Provide completely programmable signal processors and enable rapid prototyping of new solutions by replacing the current collections of "hardwired" special purpose boxes with flexible, scaleable systems based on High Performance and Adaptive Computing (HPAC) technologies.
- Keep C4I systems current and foster competition by using open systems architectures.

Major Accomplishments

- Developed Adaptive Signal Processing technique for non-homogeneous clutter suppression applicable to AWACS.
- Designed and prototyped the High Performance Scaleable Computer two-level multicomputer architecture.
- Demonstrate nonlinear signal processing and neural network technologies applied to communication processors.
- Demonstrated four-channel, real-time, speaker and language identification.
- Demonstrate rapid prototyping capability for evaluating advanced communications/signal processing concepts.
- Demonstrate wavelet Transform based spread spectrum interference suppression subsystem.
- Demonstrate highway monitoring system via video sensor technology for real-time traffic management.
- Demonstrate an ultra-wideband (UWB) communications system, capable of a rate of six megabites/second using an Acoustic Charge Transport neural network as broadband nonlinear filter.
- Designed and fabricated Multichip Modules (MCM) for Wafer Scale Signal Processor.

Changes From Last Year

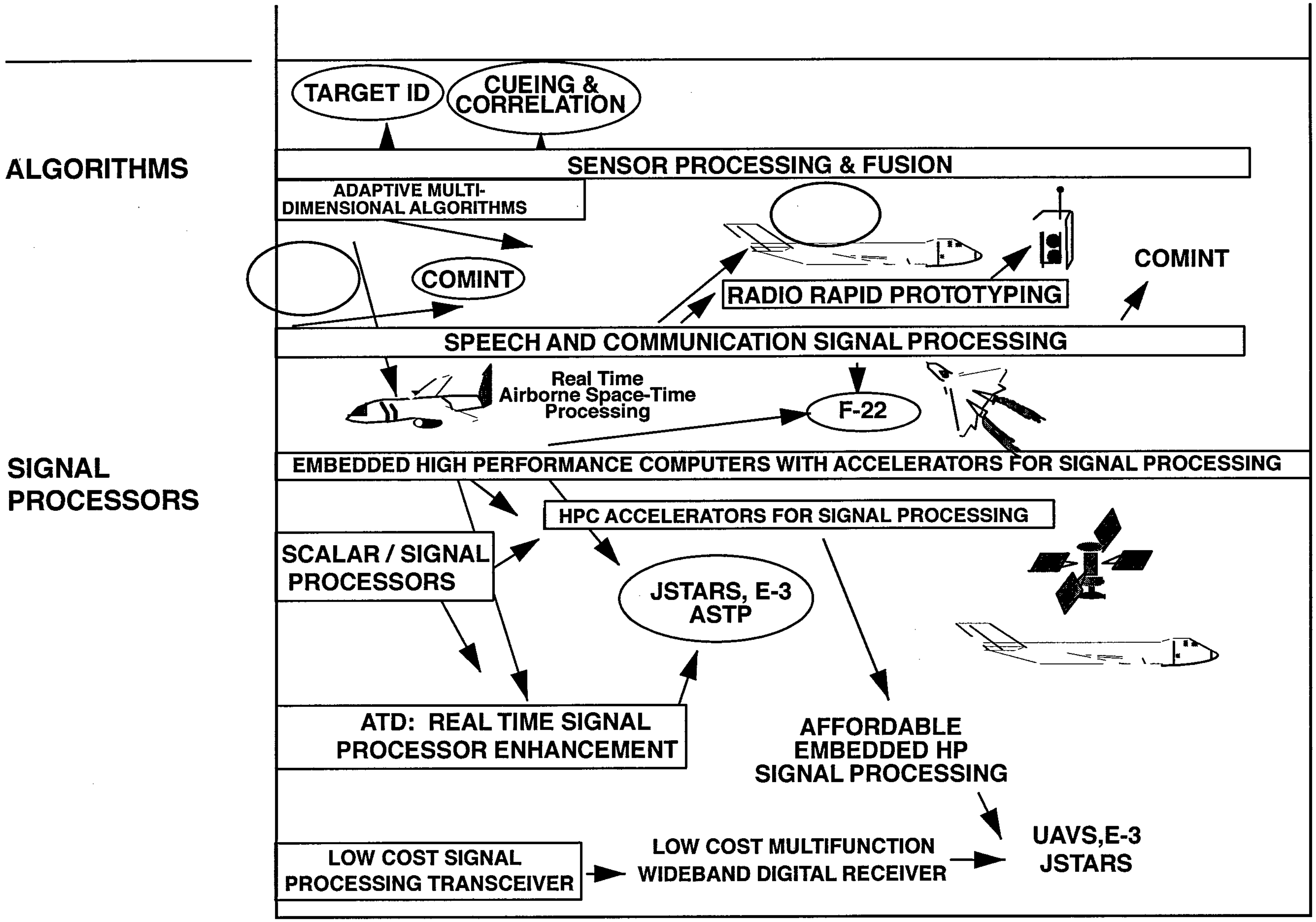
Low Cost Tera Flop Computer initiative was terminated due to inadequate funding in FY98-FY00.

Milestones

The signal processing thrust emphasizes the interrelated areas of developing new signal processing algorithms or techniques, and developing high performance signal processors based on commercial off the shelf (COTS) High Performance Computing (HPC) technology.

1998:

- Demonstrate a seamless communications design environment from high-level software through to hardware implementation via soft-hardware.
- Automated sorting of signals to improve tactical intelligence processing by 50 percent.
- Evaluate embedded parallel processing architecture for integrating wafer scale signal processor chips for a real-


ALGORITHMS
SIGNAL PROCESSORS
TARGET ID
CUEING & CORRELATION
SENSOR PROCESSING & FUSION
ADAPTIVE MULTI-DIMENSIONAL ALGORITHMS
COMINT
RADIO RAPID PROTOTYPING
COMINT
SPEECH AND COMMUNICATION SIGNAL PROCESSING
Real Time Airborne Space-Time Processing
F-22
EMBEDDED HIGH PERFORMANCE COMPUTERS WITH ACCELERATORS FOR SIGNAL PROCESSING
HPC ACCELERATORS FOR SIGNAL PROCESSING
SCALAR / SIGNAL PROCESSORS
JSTARS, E-3 ASTP
ATD: REAL TIME SIGNAL PROCESSOR ENHANCEMENT
AFFORDABLE EMBEDDED HP SIGNAL PROCESSING
LOW COST SIGNAL PROCESSING TRANSCEIVER
LOW COST MULTIFUNCTION WIDEBAND DIGITAL RECEIVER
UAVS,E-3 JSTARS

time signal processor enhancement demonstration.

- Evaluate knowledge based adaptive techniques necessary for airborne monostatic and bistatic radar applications.
- Demonstrate in lab environment embedded parallel processing architecture for integrating accelerator nodes for real time applications for JSTARS and AWACS.
- Develop follow-on multichip module wafer scale signal processor capable of 20 billion operations per second for Real Time Signal Processor Enhancement ATD and BMD ASTP initiative.
- Develop Standard Libraries and Message Passing Interfacing for improving signal and image processing HPC efficiency.
- Transition Constant False Alarm Rate (CFAR) techniques to AWACS.

1999:

- Demonstrate advanced communication signal processing on HPC architectures with the wafer-scale signal processor.
- Demonstrate an advanced communications engine, developed under DARPA TRP, to support multiband/multimode radio functions.
- Knowledge-based applications to Space-Time Adaptive Processing for improved detection of weak targets in the presence of severe clutter and jamming.
- Transition Target ID algorithms to AWACS.
- Demonstrate miniaturized spoken language translation for Special Operations Forces application.

2000:

- Demonstrate initial capability of Smart Radio system, including advanced network and link level capabilities.
- Transition Adaptive and Reconfigurable Computing hardware and software tools for SAR applications.
- Demonstrate an affordable, power efficient embeddable signal processor architecture for transition to an unmanned aerial vehicle (UAV) platform.
- Transition automatic audio based activity recognition to AFMC / DET2.

THRUST

The key to our sustained military supremacy is enhanced mission productivity and increased command and control agility across the force structure through the use of computer systems and advanced software to perform mission critical functions in a globally dispersed theater of operations. Thus:

- **AFMC, AETC, ACC and the other MAJCOM's** need better pr elop- ment, and post deployment support of mission critical software systems.
- **ACC, AFSOC, USTRANSCOM, AMC,** etc. are concerned with the dependability, adaptability, survivability, security, interoperability with dissimilar systems, "real-time" information access capability, and timely executable plans, etc., fr

These needs are documented in the AFMC/ESC Technology Needs, the ACC Strategic Defense and Theater Battle Management MAPs and the AFSOC Weapon System Roadmap.

Specifically, this thrust addresses:

- Technology, tools, processes and whole "environments" to elopment and support of military software intensive systems. The emphasis is on new capabilities enabling software to evolve gracefully over extended life-times in dynamic environments.
- The achievement of secure, dependable, immediate, and -

  er systems and databases resulting from distant, and/or ces' missions.
- Tools for rapidly generating, evaluating, optimally scheduling, and execution management of combat, transportation, r -

  ble "quick reaction" force structure needed.

- Increased military readiness through software systems that are malleable in the context of new or changing operational situations.
- 10:1 throughput performance enhancement in distributed computing, achievement of real-time performance in multi-media databases, and achievement of top NSA security standards in distributed computing and databas-

  es all in suppor -

  sions.
- Factors of 10 to 1000 reduction in times required by the Joint Chiefs on down, for planning and scheduling com- -

  port activities. Eighty percent reduction in the in-theater "footprint" required for C2 battle staffs.
- Natural human interface to complex C4I systems by the integration of multi-media, virtual reality, high resolution displays and spoken language.
- Demonstrated an integrated planning, force generation,

  and ex -

  orative venue supporting all levels of the command structure from the Unified CINC to Air Operations Center (AOC) at JWID 96.
- Laptop In-Theater Airlift Scheduling (ITAS) brassboard is operational at PACAF. This technology is also being incorporated in the Consolidated Air Mobility Planning Systems (CAMPS).
- Rome Laboratory's Knowledge-Based Software Assistant (KBSA) pr -

  om -

  nomical production of high quality and performance software a reality for the first time. The KBSA Advanced Development Model (ADM) creates a new software lifecycle paradigm, greatly increasing productivity and quality by capturing and transforming user requirements and

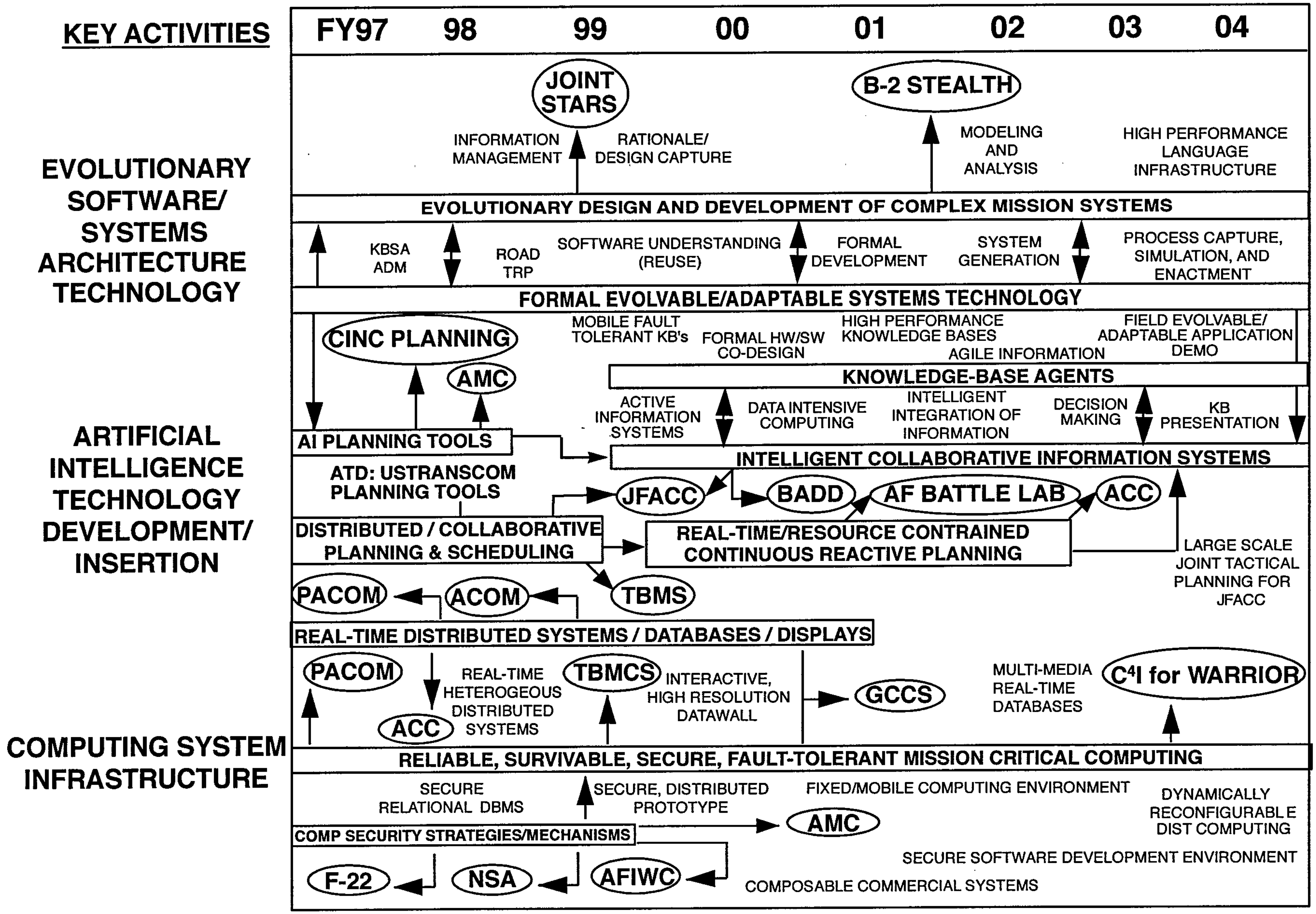
- The joint DARPA and Rome Laboratory Evolutionary Development of Complex Software (EDCS) program -

  ogy to enable continuous evolutionary development of families of long-lived military software systems. These net-based demonstrations were accomplished within realistic military application scenarios.
- Rome Laboratory completed the Software Certification Program which developed a framework for certifying software components. The program goal was to make software component cer

  cost-effective, thereby increasing the overall reliability of software products.
- Catalyst V1.0, a system/software environment infrastructur -

  neering tools/databases was delivered to Rome Laboratory and Northrop Grumman Corp., and was employed to

COMPUTER SCIENCE AND TECHNOLOGY



demonstrate advanced capabilities in support of Joint STARS OFP evolution. Catalyst is based on the common object request broker architecture (CORBA).

- Rome's Cronus Distributed Computing Environment was extended to include new CORBA commercial requirements and used to demonstrate the concept of distributed Air Task Order generation and execution monitoring in JWID 96.

- Demonstrated to ACC/DR and at Fort Franklin (ESC) knowledge-base enhancements to advanced air operations process plan authoring tools, allowing integration of consistency checking, plan feasibility analysis and what-if analysis within strategy-to-tasks, objectives based air component planning and plan viewing.

- Established an ATM connected distributed computing testbed called JADEnet with NRaD and US Army CECOM for wide bandwidth application testing.

- Extended the local cluster of the secure distributed computing environment capability to demonstrate heterogeneous hosts and a B3 level of trust.

The directed elimination of "conventional or classical" soft-

CHANGES FROM LAST YEAR

ware engineering and the curtailment of work in Advanced Parallel Computing because of reductions in resources and personnel resulted in the merging of the KBSA and joint RL/DARPA EDCS programs, yielding a strong program with emphasis on capabilities to allow continuous evolutionary development of families of long-lived military software systems and the investigation of technology to produce systems which may be adapted in the field to meet mission and environmental changes.

1998:

MILESTONES

- A secure Real Time Distributed Computing Environment (RTDCE) will be realized.

- Demonstrate separable active data dissemination architecture for integrated access and cooperation among functionally independent intelligent information systems.

- Demonstrate a hybrid distributed computing environment with both fixed and mobile nodes.

- Develop a very high resolution, interactive display in support of Rome Laboratory's JFACC testbed using a "Datawall" display with "direct pointing" and "spoken-language" interface.

- Demonstrate initial independent capabilities to support lifetime evolution of software systems for restricted domains.

- Demonstrate generation of code from architectural specification language.

- Demonstrate advanced scheduling performance speedups of five times, minimum perturbation scheduling and rescheduling.

- Demonstrate integrated case-based and generative techniques to speed planning, scheduling and evaluation by five times.

- Demonstrate ability to detect impact of new constraints and situations as needed to trigger timely replanning, including interleaved planning and execution processes triggered by live data monitoring.

1999:

- Demonstrate performance prediction and effectiveness tools to achieve mission time response needs for the Joint Stars Program.

- Demonstrate timely access, storage, change detection techniques using high performance intelligent information systems integrated with massively large multi-source knowledge bases.

- Demonstrate user adaptable/evolvable software allowing automated reconfiguration to accommodate environmental and mission changes.

- Demonstrate performance prediction and effectiveness tools to achieve mission time response needs for the Joint Stars Program.

- Demonstrate techniques to certify the real-time properties of systems and incremental recertification of evolutionary system.

- Demonstrate integrated planning techniques for force employment/deployment accelerating current processes by 10 times.

- Demonstrate focused replanning, triggered by semi-automated execution monitoring agents, in interleaved planning/execution processes showing 10 times reduction in time needed for responding to plan breakdowns.

2000:

- Demonstrate evolutionary capability in military application software.

- Demonstrate very large knowledge/information axioms of battlefield and crisis management knowledge to JFACC, ALP, DMIF and GENOA.

This thrust provides the enabling electromagnetic technol-

THRUST

ELECTROMAGNETIC TECHNOLOGY

USER NEEDS

ogy for next generation surveillance and communication systems. This technology supports advanced user needs from **Air Combat Command, Air Mobility Command, Air Force Space Command, and Air Force Special Operations Forces.**

ACC, as lead for all MAJCOMS, is the primary customer for **Theater Battle Management (TBM)** technology. Specific needs, delineated in the **ACC TBM Mission Area Plan (MAP)** are:

- Efficient/effective viewing of air situation and early reporting of data for theater missile defense.
- Early launch detection and assessment.
- Improved detection of low observable targets in clutter.
- Improved communications to all force and C2 elements with real-time capability.

The **AMC Airlift MAP** identifies needs for improved anti-jam, secure communications providing teleconferencing, patient-in-transit visibility, high data rate digital file and image transfer, and robust automatic dependent aircraft surveillance. Technologies supporting these needs include the better understanding of multi-band SATCOM.

The **Air Force Space Command's Command and Control MAP** addresses the need for high data rate satellite cross links and efficient communication switches. Technologies supporting these needs are the electromagnetic materials and millimeter wave solid state component research, which also support ACC and AMC mission needs.

The **Air Force Special Operations Forces (SOF) Weapons Systems Roadmap** identifies the need for secure, interoperable communications with low probability of detection and intercept. Thrust efforts enabling these SOF capabilities are secure, anti-jam, Low Probability of Intercept (LPI) systems for inter-aircraft communications, navigation, high data rate image transfer via satellite, and long endurance, psychological operations with low drag, wideband aircraft antennas.

- 1,000-fold improvement in the ability to detect and track

GOALS

low observable (LO) targets.

- 100-fold increase in satellite communication and covert communication terminal sensitivity or 10-fold reduction in terminal size allowing more frequent updates to users.
- Ten-fold reduction in the life cycle cost of phased array antennas for these systems.

Significant progress was made in technology development for advanced, high data rate communications, especially for

MAJOR ACCOMPLISHMENTS

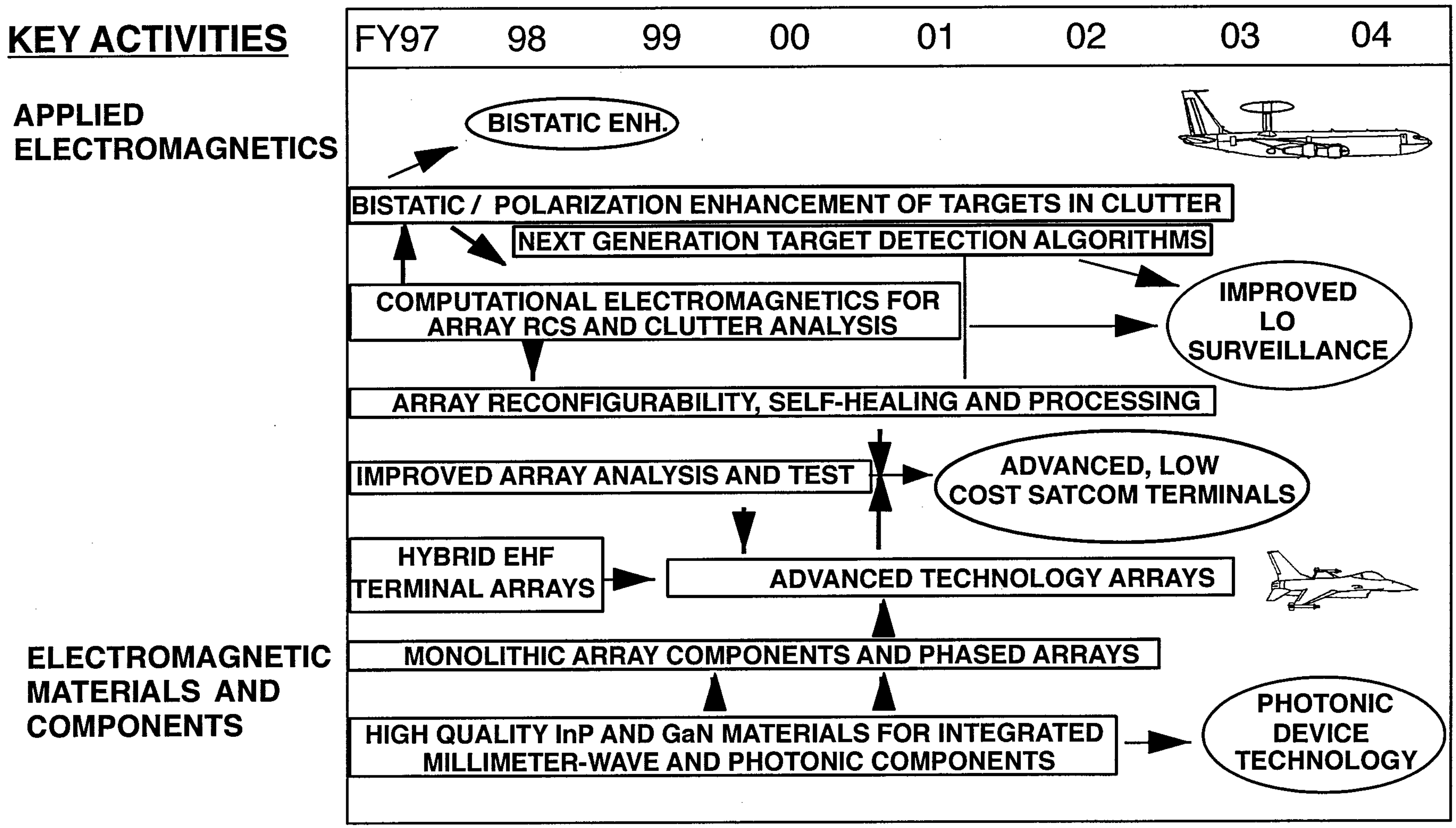
satellite and covert communications.

- A 1500 element 12 GHz array was successfully demonstrated on the AF Speckled Trout aircraft during JWID 96. This phased array technology has been transitioned to a commercial product. Boeing is marketing this technology to receive TV entertainment on commercial aircraft.
- An in-house designed monolithic two-stage V-band amplifier to be used in a low cost communications system has achieved the highest published power added efficiency (35 percent) to date.
- Several microstrip models for 45 degree bends and T junctions were found inaccurate at millimeterwave frequencies, causing higher design costs and lower accuracy. Recommendations for fixing the problem have been published.
- The feasibility of multidimensional, optically excited semiconductor array elements in both series and parallel configurations has been shown. This is the basis for a 3-D phased array radar concept for target tracking and IFF.

Advanced high performance electronic materials are critical to advances in components, enabling high data rate communications and integrated electronic/optical processing. In particular, Rome Laboratory is an internationally recognized pioneer in InP materials and devices. Moreover, Rome Laboratory is now making significant contributions to the newly-important area of wide bandgap nitrides.

- Elimination of a hydrogen-indium-vacancy center was shown to be a key factor in a new annealing process for semi-insulating (SI) InP wafers that contain minimal amounts of iron. This discovery points the way to more reliable components. SI InP wafers are the platforms of future generations of high-frequency-high-data-rate communications, avionics, and radar components.
- Experimental boundary conditions and "sanity checks" for comprehensive modeling and simulation work on high-pressure InP crystal growth have been furnished by Rome Laboratory scientists. The modeling, conducted by a consortium of universities led by SUNY Stony Brook, simulates conditions in Rome Laboratory's unique crystal growth furnace, and is being used to develop the next generation of commercial high pressure systems for

ELECTROMAGNETIC TECHNOLOGY



growing semiconductor crystals. This work will lead to higher quality InP wafers at significantly reduced cost, paving the way for economical high-frequency-high-data-rate communications, avionics, and radar components.

- A novel "close-spaced" OMCVD injector was designed, in a collaboration with EMCORE Corp., to deposit wide bandgap nitride semiconductor films. Such films will be used to fabricate electronic devices that can withstand high temperatures and require no cooling, and for UV/blue emitters and detectors that will be used for secure communications, high density data storage, and missile warning.

High performance, surveillance radar systems capable of counter LO capability are made possible by the following technology advances:

- A neural network controller was designed and used to successfully control the phase shifters of a C-band, analog beamformer phased array antenna. This allowed accurate steering of the array main beam in the presence of severe near field scattering effects.
- Development of graphical bistatic radar cross section code for rapid real time RCS prediction.
- Found that wide-angle transmitter/receiver separation maximizes target RCS, permitting smaller, low-cost platforms for airborne bistatic radar systems.
- Confirmation of 20 dB improvement in the detectability of LO targets using bistatic radar polarization diversity.

Technology efforts for low-probability-of-intercept trans-

CHANGES FROM LAST YEAR

mission and signals intelligence for SATCOM have been eliminated.

A new research effort for light-weight array antennas for UAV's has begun with support from an AFOSR New World Vistas Initiative.

1998:

MILESTONES

- Demonstrations of simultaneous near-field and far-field nulling are planned to show antenna pattern control of airframe scattering and jammer cancellation.
- Second generation compact, low cost, gallium arsenide (GaAs) active phased array antennas for EHF satellite communications for aircraft platforms will be demonstrated.
- A sigma-delta A/D converter with bandwidth and resolution (50 MHz, 14 bit) exceeding current capability will be demonstrated. This will lead to an extremely low power, single chip A/D modules with superior performance for beamforming applications.
- A 60 GHz monolithic InP transmit chip, including an amplifier and phase shifter, will be characterized.
- A 3-D optically excited array will be designed and built.
- Growth of bulk gallium nitride in new high pressure ammonothermal crystal growth apparatus will be demonstrated.

1999:

- An advanced in situ InP synthesis-plus-bulk-crystal-growth process will be developed and transferred into the US defense and commercial industrial bases.
- Understanding of bistatic clutter characteristics of varying terrain types at high (up to 10 degrees) grazing angles will be formalized.
- A neural network based algorithm will be developed to perform a multiple source direction finding (DF) function using a cylindrical sector phased array antenna.
- A monolithic millimeterwave low noise amplifier (LNA) with noise and gain performance exceeding that presently available will be designed and demonstrated. This will use our Advanced HEMT III-V technology.

2000:

- Substantial wide angle bistatic RCS enhancement on stationary and moving targets will be demonstrated.

2001:

- A light-weight sub-array will be demonstrated for incorporation in a conformed, multifunction phased-array antenna on a UAV.
- Chip cage concept for rapid field-replaceable components will be demonstrated.

Current electronic systems are susceptible to electro-mag-

USER NEEDS

netic interference. Size constraints, speed and reliability also limit traditional electronic systems. Photonics based systems, that process information in the form of light (photonics) signals, will provide major improvements in tactical and strategic command, control, communications, and intelligence systems by providing small size, high performance, high capacity, survivable alternatives to electronic based systems.

- The **Air Combat Command (ACC) Reconnaissance and Surveillance Mission Area Plan (MAP)** identifies timeliness, collection and storage at very high data rates, and multisensor processing as deficiencies in current reconnaissance and surveillance systems.
- The **ACC Strategic Defense MAP** identifies a vast increase in the volume of information to be processed and the inability of current systems to handle this increased workload effectively. The capability to rapidly process sensor and intelligence information is identified as a severe limitation.
- The **ACC Theater Battle Management MAP** requires battle damage assessment in real time. Automatic target identification and infrared detection of theater ballistic missiles are identified as planned enhancements to current systems.
- **Air Force Special Operations Command (AFSOC)** identified operational requirements for faster utilization of data, greater databases, mission planning and rehearsal, and massive data storage with rapid access.
- The **Air Force Space Command Communications and Space Based Communication MAP** requires low power input, multiple beam, null steering antennas for MILSATCOM, and low weight, low power signal processors for critical satellite communications.
- **Air Intelligence Agency Functional Area Plan Deficiency** requires remote, low loss, low distortion microwave remoting systems.
- The **Air Force "New World Vistas" Sensors Panel Report** calls for a program to significantly improve the state-of-the-art in multifunction RF apertures for radar and communications from 1 to 160 GHz. The panel also calls for the development of hyperspectral sensors for target identification and suppression of clutter and camouflage.

- High capacity/rapid access memory (one thousand tril-

GOALS

lion bits with nanosecond access).

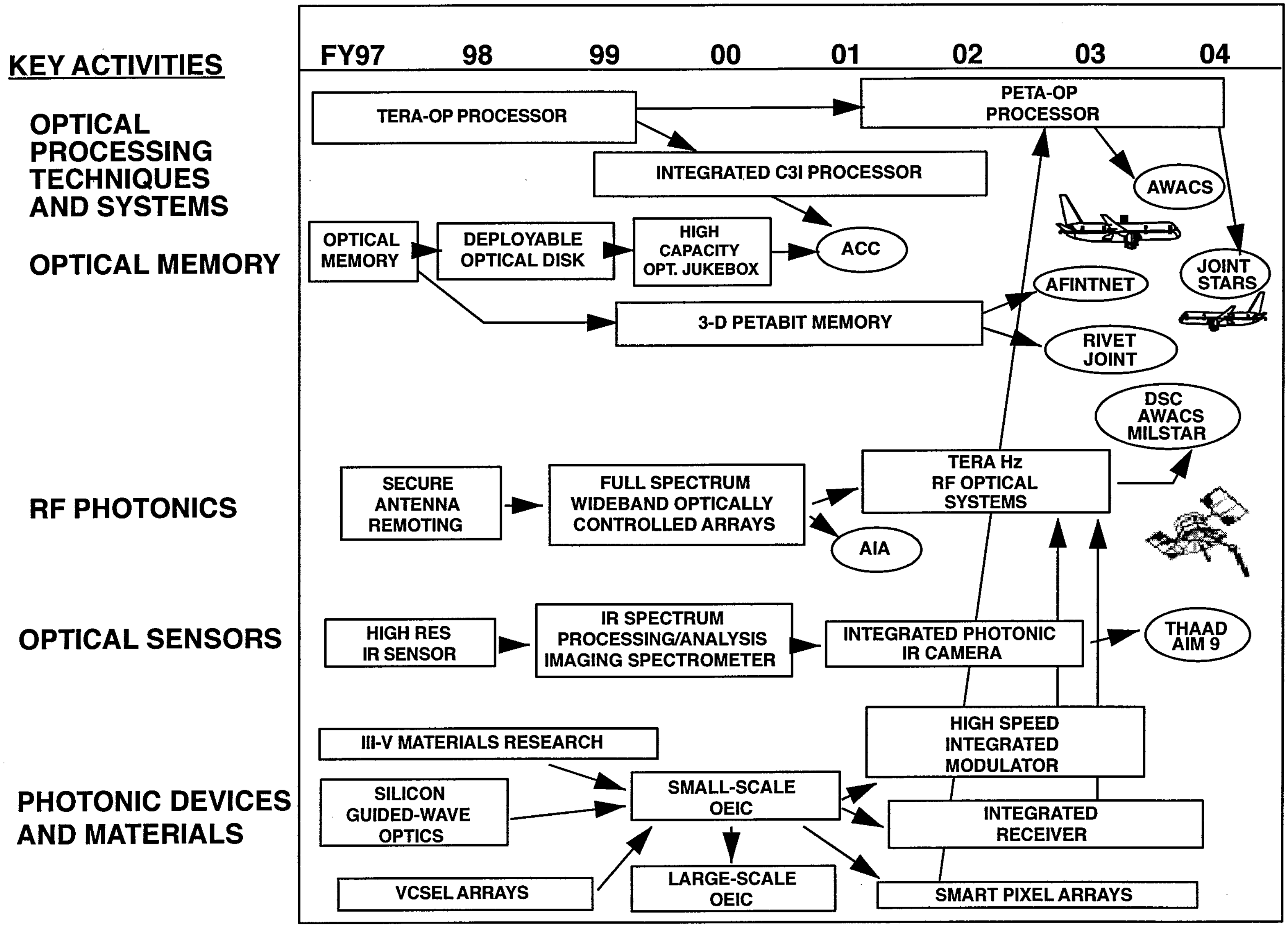
- Full spectrum infrared sensor systems.
- Photonics based RF systems.
- Wideband, multi-frequency, multi-beam antenna systems.
- Small, high speed and performance, signal processors.
- Integrable opto-electronic devices.
- Demonstrated a super fast method of detecting defects in

MAJOR ACCOMPLISHMENTS

gallium arsenide wafers using a platinum silicide, (PtSi) focal plane array camera.

- An optical disk jukebox/magnetic disk RAID memory system was delivered and integrated with AFINTNET at the 480th Intelligence Group.
- Established a Fiber Grating Fabrication Facility (FGFF) to write Bragg gratings on fiber optic cable.
- Demonstrated thermal stability to 700 degrees Celsius of zinc oxide (ZnO) a promising material for wide bandgap nitride semiconductors.
- Received an in-house patent for an optical monopulse chirp processor with potential for high performance clutter rejection in a low cost, simple system.
- Improved three-fold the diffraction efficiency of bismuth silicate (BSO) in four-wave mixing for optical processing by co-doping with manganese and phosphorus.
- A 600x800 spatial light modulator and a diode pumped laser were integrated and tested in the 3-D memory cube for WORM operation.
- Demonstrated two approaches to improve the depth of modulation (signal) at microwave frequencies by reducing the optical carrier. These techniques increase dynamic range and prevent power saturation.
- Fabricated and demonstrated femtosecond pulses on a fiber optic laser for terabit communication rates.
- Developed a liquid encapsulated zone melting technique and grew uniform bulk crystals of silicon-germanium.
- The feasibility of using holographic optical digital disks to replicate multiple copies of Read Only Memory (ROM) data was demonstrated.
- Completed the design of a photonically implemented SHF SATCOM phased array.
- Fabricated working indium gallium arsenide (InGaAs)

PHOTONICS


KEY ACTIVITIES
OPTICAL PROCESSING TECHNIQUES AND SYSTEMS
OPTICAL MEMORY
RF PHOTONICS
OPTICAL SENSORS
PHOTONIC DEVICES AND MATERIALS
FY97
98
99
00
01
02
03
04
TERA-OP PROCESSOR
PETA-OP PROCESSOR
INTEGRATED C3I PROCESSOR
AWACS
JOINT STARS
OPTICAL MEMORY
DEPLOYABLE OPTICAL DISK
HIGH CAPACITY OPT. JUKEBOX
ACC
3-D PETABIT MEMORY
AFINTNET
RIVET JOINT
DSC AWACS MILSTAR
SECURE ANTENNA REMOTING
FULL SPECTRUM WIDEBAND OPTICALLY CONTROLLED ARRAYS
TERA Hz RF OPTICAL SYSTEMS
AIA
HIGH RES IR SENSOR
IR SPECTRUM PROCESSING/ANALYSIS IMAGING SPECTROMETER
INTEGRATED PHOTONIC IR CAMERA
THAAD AIM 9
III-V MATERIALS RESEARCH
SILICON GUIDED-WAVE OPTICS
VCSEL ARRAYS
SMALL-SCALE OEIC
LARGE-SCALE OEIC
HIGH SPEED INTEGRATED MODULATOR
INTEGRATED RECEIVER
SMART PIXEL ARRAYS

light-emitting diodes with long lifetimes on silicon.

- Began fabrication of a 48 element photonically implemented SHF phased array antenna as part of an ATD for an airborne Defense Satellite Communications System (DSCS) compatible antenna.

- Designed and submitted for patent a low cost, chip-to-chip and board-to-board optical interconnect.

- Demonstrated a room temperature reverse polarized lithium niobate chip for an electro-optic modulator with improved dynamic range and velocity matching.

- Designed, fabricated, and demonstrated a blue light fiber laser for writing to a high density optical disk.

- Began the competitive design of a photonically implemented EHF SATCOM phased array for use in airborne applications such as MILSTAR.

- Patented and developed a high capacity, photo-chromic tungsten oxide compact disk storage system.

- Demonstrated high power optical detectors.

- Completed design and began fabrication of a hybrid photonic/electronic neural network system.

- Developed a new technique for using waveguide gratings in photonically implemented phased array antenna beam forming and steering.

- Demonstrated optical modulators at unprecedented, high frequencies with extremely good dynamic range.

- Developed and began laboratory verification of a simulation of a figure-eight laser system that eliminates practical limits on the laser cavity length.

There were no changes from last year.

Changes From Last Year

1998

Milestones

- Deliver and beta test a 3-D optical read only memory (ROM) device with terabit capacity, gigabit throughput rate, and nanosecond access time.

- Demonstrate a brassboard integrated C4I optical processor emphasizing optical interconnects for near real-time interactive processing of sensor, intelligence, and imaging systems.

- Use on MWIR PtSi sensor in dual-band imaging.

- Deliver and integrate into AFINTNET a one terabyte erasable optical disk jukebox for the 480IG (AIA).

- Demonstrate epitaxial transfer integration to develop hybrid III-V optoelectronic integrated circuits on ceramic, organic, and semiconductor substrates.

- Demonstrate ultra-high and low fluence optical detectors using bandgap engineering and advanced surface passivation technology at 1.3-1.5 μm.

- Develop a high performance silicon/indium gallium arsenide absorption and multiplication avalanche photodiode using semiconductor fusion technology.

1999:

- Demonstrate bulk growth of ternary III-V semiconductors to extend the range of materials available for lasers, detectors, and transistors.

- Demonstrate hyperspectral sensing using tomography in the 1.0-3.5 μm spectral region.

- Deliver for beta testing a 3-D optical WORM device with terabit capacity, gigabit throughput, and nanosecond access time.

- Begin demonstrations of optically controlled phased arrays for airborne application at SHF for the DSCS.

- Demonstrate a fully integrated infrared optical processor that can resolve color imagery.

- Integrate at the 480IG (AIA) an electro-optic data transport system to interface all 3-D and 4-D optical memories to existing computer networks.

- Develop a packaged, high-speed, vertical cavity surface-emitting laser for room temperature, continuous wave operation at 1.3-1.5 μm.

- Initiate a demonstration of a comprehensive RF signal distribution system ATD for secure remoting for all radio frequencies up to 100 GHz.

- Demonstrate tomographic 3-D sensing from 1-3.5 μm.

2000:

- Deliver a 3-D optical erasable memory device with terabit capacity, gigabit throughput, and nanosecond access time.

- Pre-prototype a 4-D, DNA optical memory device.

- Demonstrate an integrated C4I optical processor (ATD) for near real-time interactive processing of sensor, intelligence, and imaging systems.

THRUST

RELIABILITY SCIENCES

USER NEEDS

The basic objective of the Reliability Sciences Thrust is to ensure that Air Force/DoD electronic systems perform their specified mission in diverse military environments. This research includes technology areas that stress development and use of tools and techniques such as: modeling and simulation, materials and process characterization, operational assessments, failure modes and effects assessment, and correction. This technology thrust is utilized by both the commercial and industrial base in the design, development, production and maintenance of cost-effective, reliable systems that meet customer needs. The Reliability Sciences Thrust provides major technical support to the Air Force Core Competencies of emphasis such as: Air/Space Superiority, Information Dominance, and Precision Deployment. Reliability and Diagnostics technology is central to the Air Force core competencies in the areas of Readiness, Sustainment, and Logistics.

This program contributes to the DoD science and technology strategic thrusts including the Global Surveillance and Communications thrust, the Precision Strike thrust, the Technology for Affordability thrust, and the Air Superiority & Defense thrust. Programs in this thrust are covered by the Electronics portion of the Defense Technical Area Plan. Additional Reliability Sciences thrust user needs are documented in DoD Advisory Group on Electron Devices (AGED) Special Technology Area Reviews; Electronics Defense Technology Area Plan; and AFMC TPIPT Technology Needs.

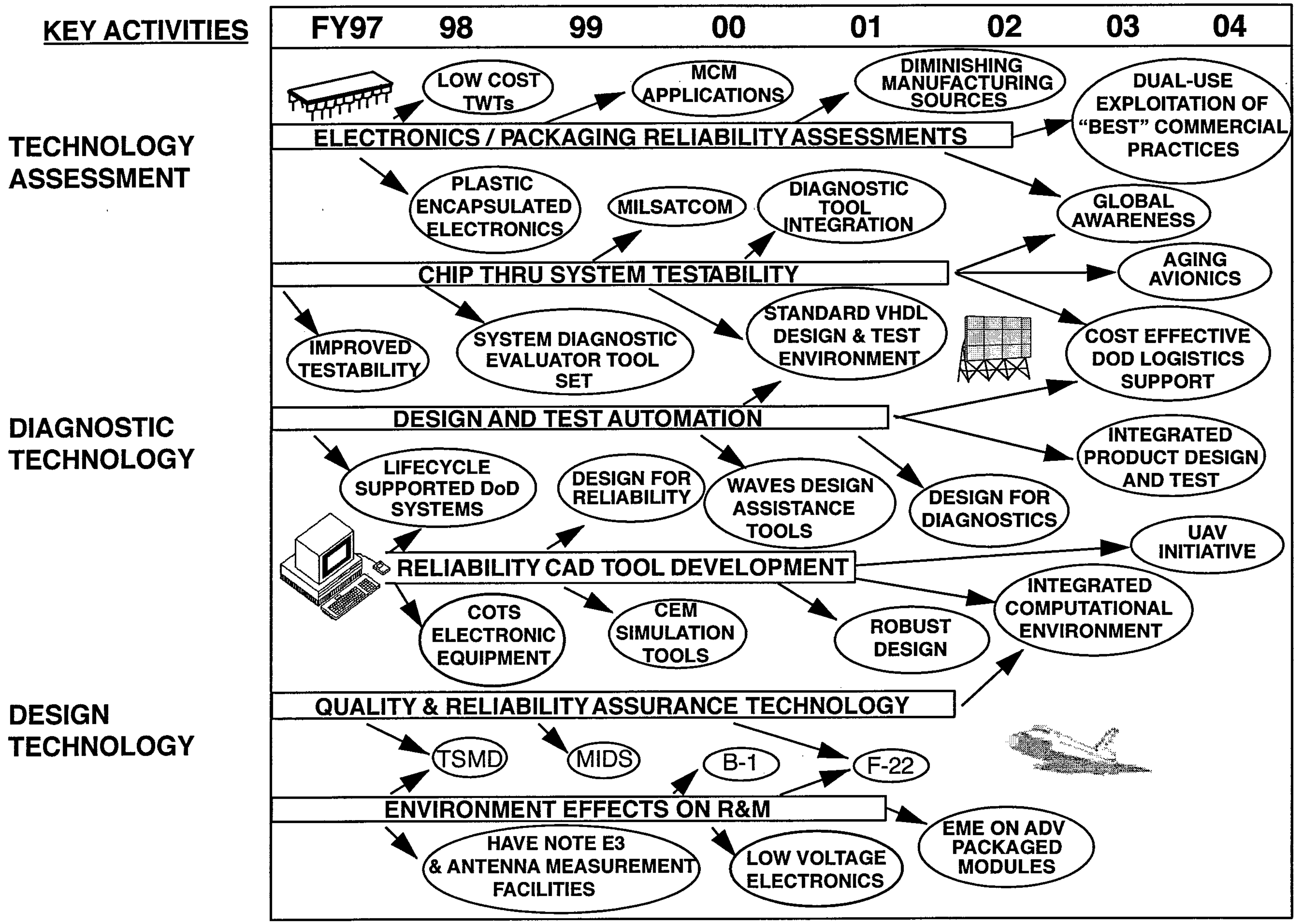
GOALS

- Achieve an order of magnitude increase in mean time between maintenance actions and a factor of four or greater decrease in support costs attributed to external test equipment, personnel, and training.
- Develop design tools and test methodologies to incorporate reliability technologies at the earliest stages of design and development for new and upgraded systems.
- Assess device and system failure modes/mechanisms and operational environmental factors to determine the stresses imposed on devices and systems, and translate this information into affordable robust system and component designs.
- Develop efficient diagnostic methodologies to reduce, by 10 fold, the high levels of unnecessary maintenance actions and to allow for on-equipment fault detection/isolation.
- Achieve increased electronics reliability and performance through identification and reduction of the effects of electromagnetic environment (EME) exposure.
- Develop tools and technologies for the successful integration of Commercial-Off-The-Shelf (COTS) components and equipment into diverse military applications.
- Investigate application of R&M techniques and tools for assessing failure points/weaknesses/vulnerabilities exploitable for information dominance purposes in C4I designs.

MAJOR ACCOMPLISHMENTS

- Developed the Larch/VHDL Hardware Design Verification Tool to verify the design of operational digital electronics, from microcircuits to system level. This tool, utilizing mathematical methodologies, provides the capability to design and fabricate systems correctly the first time eliminating costly and time comsuming redesign and rework. This tool will enable verification of the correctness of a design early in the development and procurement phase of military systems and will be a vital element in controlling the life cycle cost of C4I systems .
- Developed a microelectronic prognostic reliability monitor to predict impending operational failure of electronic components, modules and systems due to hot carrier degradation and oxide breakdown. These cells are self stressing structures which accelerate failure in a manner similar to wafer level reliability tests. They have been designed to operate in a stand alone manner with integration into the IEEE 1149.1 Boundary Scan Test Access Port (TAP). The cells and test methodology will be incorporated into future AF system designs, improving predictive maintenance, reducing cost and availability, and improving reliability and maintainability.
- Developed a novel approach for efficiently supporting flexible multiprocessing and fault-tolerant computing. This method, the Dynamic Reconfigurability Assisting Fault Tolerance and Multiprocessing (DRAFT/MP) Architecture, provides a high-speed controller that provides a message-passing interface between large numbers of loosely coupled computing modules in a distributed computing system. Easily implemented using off-the-shelf integrated circuits (ICs), this approach is low cost as well. Previous approaches have been either hardware-based (fast, but inflexible), or software-based (flexible, but slow). This makes DRAFT/MP applicable to real-time C3 systems that demand high performance and high assurance.
- Developed techniques for antenna range multipath suppression systems to identify and suppress stray multipath

RELIABILITY SCIENCES



signals which can seriously affect the performance validation of advanced antenna systems. Advanced antenna systems, such as the Ultra Low Sidelobe Array, are extremely sensitive to extraneous electromagnetic signals and controlling these signals is essential to insure accuracy of performance validation measurements. The technologies use sophisticated signal processing techniques to perform the signal identification and suppression functions. They will be implemented at the Rome Laboratory Antenna Measurement Facilities to the validate the performance of new advanced Low Sidelobe Antenna Systems.

Changes From Last Year

The Reliability Sciences Thrust was reduced to pilot light status for FY98, FY99 and FY00 as part of the Air Force's FY98 S&T POM strategy. This will result in the following actions:

- Eliminates support for the Air Force's Acquisition Reform Initiative of "Performance Based Requirements"to reduce costs and more quickly and cheaply insert state of the art technology into existing weapon systems.
- Terminates technology that addresses near term requirements associated with the Aging Avionics and UAV Initiatives.
- Severely reduces efforts in the development of diagnostic and test technology for avionics systems (F-22, F-16, F-15, B-1, JSTARS and E3A).
- Eliminates antenna platform modeling for advanced sensors which reduces avionics prototyping/development costs.
- Eliminates assessments of technologies targeted for insertion into precision munitions, conventional bomber upgrades/modifications and other core competency programs.
- Loss of DoD unique research facilities due to lack of maintenance.

Milestones

1997:

- Develop the requirements and architecture necessary to develop a System Diagnostic Evaluator tool or tool set to support efficient diagnostic design process trade-offs and provide cost-effective means for evaluating the diagnostic performance of electronic systems.
- Develop a software tool set that will provide fault injection, fault simulation, and test generation within an industry standard VHDL design and test environment.
- Develop a cost/performance based tool for use in assessing the suitability of commercial-off-the-shelf electronic equipment for use in diverse military operational environments.
- Develop Advanced Computational Electromagnetics (CEM) simulation tools for analyzing the performance of complex antennas/arrays while mounted on their operational platforms.
- Develop a low cost, capable Environmental Measurement Device(EMD) for the military logistics/supply community and the commercial transportation industry to measure and record environmental stresses during transportation to reduce the current one billion dollar per year damages suffered by the transportation industry.

1998:

- Develop an Automated Design Environment for Reliability Trade-off assessments and robust implementations.
- Evaluate low-power, low-voltage device technology for reliable, survivable C4I systems from device process level to high-level system design and synthesis.
- Investigate and develop Built In Self Test (BIST) techniques, strategies and objects for analog and commercial off the shelf (COTS) circuitry.
- Develop a small, low power, broadband, frequency discriminating electromagnetic field sensor to enhance realtime reliability and maintainability assessments of the radio frequency interference environment on C3I platforms.
- Investigate the use of Silicon Germanium (SiGe) technology for mixed digital/microwave applications, such as in transmit/receive (T/R) modules.
- Develop a tool-independent, open-architecture framework for microelectronic devices and their packages which will link physical descriptions with simulation and behavioral models such as thermal, electrostatic and electromagnetic analyses.

GLOSSARY

3D: *Three Dimensional*
ACC: *Air Combat Command*
ACCINTNET: *ACC Intelligence Network*
ADM: *Advanced Development Model*
AF: *Air Force*
AFAE: *AF Acquisition Executive*
AFMC: *Air Force Material Command*
AFOSR: *Air Force Office of Scientific Research*
AHDL: *Analog Hardware Descriptive Language*
AI: *Artificial Intelligence*
AIA: *Air Intelligence Agency*
AJ: *anti-jam*
ALC: *Air Logistics Center*
AMC: *Air Mobility Command*
AOC: *Air Operations Center*
APS: *Advanced Planning System*
ARO: *Army Research Office*
ASARS: *Advanced Synthetic Aperature Radar System*
ASIC: *Application Specific Integrated Circuit*
ATAF: *Allied Tactical Air Forces*
ATD: *Advanced Technology Demonstration*
ATM: *Asynchronous Transfer Mode*
ATO: *Air Tasking Order*
ATR: *Automatic Target Recognition*
ATS: *Automatic Test System*
AWACS: *Airborne Warning and Control System*
BEA: *Budget Estimate Agreement*
BM: *Battle Management*
C^2: *Command and Control*
C^3: *Command, Control, and Communications*
C^4I: *Command, Control, Communications, Computers and Intelligence*
CAD: *Computer Aided Design*
CASE: *Computer Aided Software Engineering*
CCD: *Charge Coupled Device*
CECOM: *Communications and Electronic Command*
CINCNORAD: *Commander and Chief NORAD*
CJTF: *Commander Joint Task Force*
CONOPS: *Concept of Operations*
COTS: *Commercial Off The Shelf*
CRDA: *Cooperative Research and Development Agreements*
CTAPS: *Contingency Tactical Air Combat System Automated Planning System*
DAMA: *Demand Assigned Multiple Access*
DARO: *Defense Airborne Reconnaissance Office*
DARPA: *Defense Advanced Research Project Agency*
DAWS: *Defense Automated Warning System*
DDR&E: *Department of Defense Research and Engineering*
DEA: *Data Exchange Agreement*
DIA: *Defense Intelligence Agency*
DISA: *Defense Information Systems Agency*
DISN: *Defense Information Services Network*
DoD: *Department of Defense*
DoDIIS: *Defense Intelligence Information System*
DSCS: *Defense Satellite Communications System*
ECRS: *East Coast Radar System*
EHF: *Extremely High Frequency*
ELINT: *Electronics Intelligence*
EM: *electromagnetic*
EP: *Education Partnership*
ESC: *Electronic Systems Center*
EW: *Electronic Warfare*
FAA: *Federal Aviation Administration*
FBI: *Federal Bureau of Investigation*
FDDI: *fiber distributed data interface*
FLEX: *Force Level Execution*
FY: *fiscal year*
GaAs: *Gallium Arsenide*
GDIP: *General Defense Intelligence Program*
GHz: *GigaHertz*
GOSG: *General Officers Steering Group*
HEMT: *High Electron Mobility Transistor*
HF: *high frequency*
ICTP: *Information Collection, Transfer & Processing*
IDHS: *Intelligence Data Handling Systems*
INFOSEC: *Information Security*
InP: *indium phosphide*
IR: *infrared*
IR&D: *Independent Research and Development*
JDL: *Joint Directors of Laboratories*
JFACC: *Joint Force Air Component Commander*
JPL: *Jet Propulson Labs*
JSTARS: *Joint Surveillance Targeting and Reconnaissance*
JWID: *Joint Warrior Interoperability Demonstration*
km: *kilometer*
LAN: *local area network*
LO: *low observable*
LPI: *Low Probability of Intercept*
MAJCOM: *Major Commands*
MAP: *Mission Area Plan*
MCM: *Multichip Module*
MILSATCOM: *Military Satellite Communications*
MIMIC: *Monolithic Microwave and Millimeter Wave Integrated Circuits*
MLV: *Medium Launch Vehicle*
MMIC: *Monolithic Microwave Integrated Circuit*
MOA: *Memorandum of Agreement*
MOU: *Memorandum of Understanding*
NAIC: *National Air Intelligence Center*
NASA: *National Aeronautics and Space Administration*
NATO: *North Atlantic Treaty Organization*
NORAD: *Northern Region Air Defense*
NRaD: *Naval Research and Development*
NRL: *Naval Research Lab*
NSA: *National Security Agency*
NTSB: *National Transportation & Safety Board*

NUWC: *Naval Undersurface Weapons Center*
NYNET: *New York Network*
NYNEX: *New York New England Exchange*
ONR: *Office Naval Research*
OSINT: *Open Source Intelligence*
OTH: *Over-The-Horizon*
P^3I: *Pre-Planned Product Improvements*
PACAF: *Pacific Air Force*
PAWS: *Parallel Assessment Window System*
PL: *Phillips Laboratory*
PSIDS: *Prototype Secondary Information Dissemination System*
PtSi: *Platinum Silicide*
QML: *Qualified Manufacturers List*
QPL: *Qualified Products List*
R&D: *Research & Development*
R&M: *Reliability and Maintainability*
RAAP: *Rapid Application of Air Power*
RCS: *Radar Cross-Section*
RL: *Rome Laboratory*
RTOK: *Retest OK*
S&T: *Science and Technology*
SAR: *Synthetic Aperature Radar*
S/TODS: *Strategic/Tactical Optical Disk System*
SATCOM: *Satellite Communications*
SBIR: *Small Business Innovative Research*
SHF: *Super High Frequency*
SIGINT: *Signals Intelligence*
SLCS: *Software Life Cycle Support*
SLCSE: *Software Life Cycle Support Environment*
SOCOM: *Special Operations Command*
SOF: *Special Operations Forces*
SONET: *Synchronous Optical Network*
SPACECOM: *Space Command*
SPAWAR: *Space & Naval Warfare System Command*
STARS: *Software Technology for Adaptable Reliable Systems*
STIG: *Space Technology Interdependency Group*
STRAMST: *S&T Reliance Assessment for Modeling and Simulation Technology*
STRATCOM: *Strategic Command*
TACC: *Tactical Air Control Center*
TACOM: *Tank and Automotive Command*
TAP: *Technology Area Plan*
TAS: *Timeline Analysis System*
TASE: *Thrust Assessment Support Environment*
TBM: *Theater Battle Management*
TCC: *Technology Coordination Committee*
TCT: *Time Critical Targets*
TDC: *Theater Deployable Communications*
TDPA: *Tactical Deception Planning Aid*
TENet: *Theater Extension Network*
TEO: *Technology Executive Officer*
THAAD: *Theater High Attitude Area Defense*
TMD: *Theater Missile Defense*
TPC^3: *Technology Panel on C^3*
TRANSEC: *Transmission Security*
Tri-TAC: *Tri-Service Tactical Communications*
TRP: *Technology Reinvestment Program*
TSMD: *Time Stress Measurement Device*
UAV: *Unmanned Aerial Vehicle*
UHF: *Ultra High Frequency*
ULPI: *Unit Level Prototype Implementation*
USACOM: *US Army Command*
USAF: *United States Air Force*
USAFE: *United States Air Force in Europe*
USSOUTHCOM: *US Southern Command*
VHF: *Very High Frequency*
VHSIC: *Very High Speed Integrated Circuit*
VLF: *Very Low Frequency*
WATCHCONS: *Watch Conditions*
WL: *Wright Laboratory*
XIDB: *eXtended Integrated Data Base*

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